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THE SUB-AQUEOUS PIPE AND ELECTRIC CABLE WAY AT GLOUCESTER, MASS.

BY HERMAN W. SPOONER, CIVIL ENGINEER, GLOUCESTER, MASS.

[Read September 15, 1908.]

Gloucester is a city by the sea, situated, with the exception of one ward, upon an island between Massachusetts and Ipswich bays, being bounded by them, together with the Squam River and canal. Of course you have heard it said that Gloucester is a part of and located upon "Cape Ann." This section of Massachusetts was a cape, years ago, before it was cut off from the mainland by the construction of the canal, that the skippers of the fishing fleet might lay a more direct course to the Grand Banks. Hence, after the canal was opened connecting the river and harbor, the cape became an island, upon which there was no opportunity to procure a supply of water sufficient to meet the steadily increasing demand.

It will be readily understood that the water mains, — the leading supply mains, — must pass under the water of canal or river at a sufficient depth below low water to cause no interference to navigation. When the plant was built, in 1884, the single supply main was laid just below the bottom of the canal, and it served its purpose until it became advisable to dredge and widen to accommodate craft at all tides, as the bed of the old canal was at the level of low-water mark, allowing no navigation even for small boats during periods of low tide.

On account of this change in width and depth, it became necessary to lower the gas and water mains to a depth of at least 19 feet below high-water mark.

Because of the nature of the ground in the vicinity of the canal, the close proximity to the only avenue by which entrance is gained to the city proper, and the waters of the harbor, it was decided that an attempt to dredge or open cut a trench to the required depth and lay twin mains therein was inadvisable. Therefore a location for vertical shafts and a connecting horizontal tunnel was considered, it being desired to avoid such locations as would cause damage to land owners, hindrance to public travel along Western Avenue, and excessive construction cost. It was decided, therefore, to make borings along a proposed line of construction southerly from Western Avenue, and wholly within lands owned and controlled by the city.

The Harbor and Land Commissioners decided that all pipes or mains should be placed at such a depth below low-water mark as to afford ample opportunity to dredge to a depth of at least 10 feet below this mark, of which only about 6 feet is to be attempted at present.

The test wells or borings were made to a depth of 50 feet below the surface of the floor of the present bridge, and in several instances about 50 feet below the bed of the canal, which is practically equal in level with low-water mark; samples of the materials encountered were procured at different levels, most of which indicated coarse gravel, sand and boulders, but no clay. As borings made north of the bridge for the Harbor and Land Commissioners indicated similar materials, and as it was evident that no clay in any amount was to be found, the final location was established on the southerly side of the avenue within the park. In 1904 plans were prepared, approved by the Water Board and the Harbor and Land Commissioners, including an alternate design, the latter being radically different from the first in all parts, and requiring the pneumatic method of construction throughout. A pamphlet covering " Notice to and Information for Bidders, Bid, Contract, Specifications and Bond " was prepared by the writer, examined and approved by the Board and the city solicitor, and forwarded to such parties as applied.

The bids were advertised in the local and contracting papers, and copies of the pamphlet delivered to fourteen applicants, eight of whom called to examine the plans and view the vicinity of the

proposed work. The samples of the materials taken from the test wells or borings were exhibited and the plans examined, and nearly all applicants decided from the location and nature of the ground through which the work was to be constructed that they would not care to bid.

One bid to do the work was filled out in the required form and filed, together with the required deposit, by Charles R. Gow and John E. Palmer, operating under the firm name of Gow & Palmer, of Boston, Mass.

The bid covering the alternate design, which will be described hereinafter, was considered by the Water Board at length. This bid covered the construction of the entire work, the price named being two hundred and fifteen dollars ($215) per horizontal linear foot for a tunnel to measure, when completed, 130 feet between the centers of the vertical shafts.

The contract and plans required that the contractors construct two circular vertical masonry shafts, interior diameter 11 feet, one on either side of the canal, surrounded to within a few feet of the surface by steel cylinders. The methods of construction were left to the discretion of the contractor, unless objection was made thereto by the writer, and it was assumed that the constructors would place the cylinders in position in a timbered square-sheathed excavation, line them with masonry of the required thickness, and then excavate from the interior, allowing the lined cylinders to settle. A tunnel 9 feet in interior diameter, having a brick wall 1 foot in thickness and incased within a cylinder consisting of steel plates, was to be constructed between these vertical shafts. After the construction of the shafts and tunnel, the contractor was required to place or imbed in concrete in the bottom of the tunnel six lines of vitrified six multiple duct extending along the entire length of the bottom of the tunnel; two lines of cast-iron pipe 20 inches in interior diameter were to be placed above the concrete in which the ducts were to be imbedded, together with a 12-inch main to convey illuminating gas, all of which were to be supported upon brick piers and extended upward through the shafts to a point about 4½ feet below the natural surface. The vertical shafts were to be divided by brick walls 8 inches in thickness into three compartments, the larger portion to be utilized

for the water and gas mains, the other part to be subdivided into two parts or quarters to accommodate high and low-tension wires or cables; both shafts were to be covered with concrete floors, entrance to be made through cast-iron manholes. After considering the bid at length, it was decided to modify the plans that the cost might be reduced, and ring timber or a cylinder of pine 6 inches in thickness to take the place of the steel plates surrounding the brick walls of the tunnel was proposed by the party presenting the bid. This alteration in the original cross-section was drafted by the writer, submitted to the bidder for consideration, and in reply a bid of twenty-six thousand dollars ($26 000) was received to complete the work in accordance with the revised plans and specifications, equivalent to two hundred dollars ($200) per horizontal linear foot.

The Water Board then awarded the contract to Messrs. Gow & Palmer. The first excavation in connection with the actual performance of the contract was made on April 4, 1905, in Marine Park, at the site of the easterly shaft. The steel cylinders, 13 feet in diameter and more than 12 feet high, together with a shorter section of special construction for use as a shoe or bottom piece, arrived by lighter on April 15 and were landed in the park, together with a hoisting engine, derrick, pumps, and other apparatus.

A circular excavation was made for the shaft, sheathed with matched plank 2 inches in thickness, the sheathing being supported by rings of 4-inch channel iron, leaving an opening in the clear of 13 feet 9 inches in which to operate. At a depth of 10 feet boulders were encountered in the coarse gravel, which were removed after blasting; water immediately began to enter the excavation in small volume and was removed by a 3-inch pulsometer pump.

At a depth of 18 feet a decided change was noted in the material, fine dead sand being found, and a decided increase in the quantity of water was evident.

On April 14, when a depth of 19 feet had been reached, the shoe-piece of the cylinder, having a special reinforced cutting edge upon which the masonry lining wall was to be constructed, was placed in position within the sheathing, and a second section of the cylinder was then adjusted, the eye (or portion which was to

be cut out later when the shaft was completely lowered, and through which the tunnel was to be started) centered, and preparation made to place the concrete lining. Fine screened sand was placed between the sheathing and the cylinder to fill the void and act as a guide, which later appeared to be an error, causing great loss of time and expense to the contractor.

While the sheathing was being placed for use as a form to support the concrete lining of the easterly shaft, an excavation was commenced on the westerly side of the canal at the site of the west shaft, in which many large boulders were found and removed after blasting, and from which the cables of the Postal Telegraph Company were removed. This opening was made in the same manner as the easterly excavation; the materials encountered at the several levels were almost identical with those found upon the east side of the canal.

The interior of the cylinder in the east shaft was treated with a three-ply coating of waterproofing, the steel receiving a coat of tar, and tarred paper being applied thereto, and this operation was continued until the desired amount had been placed.

Forms of dressed $1\frac{7}{8}$-inch plank were erected, supported within by rings of double angle-iron, allowing for the placing of concrete 1 foot in thickness inside the waterproofed cylinders. The following mixture of concrete was required and placed: To each 380 pounds of dry Portland cement there was added 5 cubic feet of fine and 11 cubic feet of coarse crushed stone, and 4 cubic feet of clean, sharp bank sand, the whole being mixed very wet.

All concrete, and all mortar used in brickwork, was mixed by hand and made with Atlas Portland cement, which passed all of the required tests which are given hereunder.

The double angle-iron rings supporting the forms were set 3 feet apart and were replaced by wooden block rings after the concrete had attained a sufficient degree of hardness. Hooked bolts were set in the concrete as the lining walls were erected, to which stagings may be attached inside the cable chambers.

When several vertical feet of the concrete lining walls had been placed, it was noted that the entire cylinder had settled about 6 inches into the gravel, the cutting edge resting upon a boulder which was found to be under the easterly edge. After this boulder

had been partially removed by blasting, the structure again settled about 3 inches. It was found that the boulder was of large size, and after continued small blasts, small amounts of powder being used on account of the close proximity of the cutting edge, the cylinder slipped past this obstruction and reached a depth of about 21 feet by easy stages.

At this time (April 24) the structure was going downward at the rate of about 20 inches in eleven hours and was becoming gradually out of plumb. The lowest portion of the edge was then blocked and the high side weighted with all available material, but no progress was made, the cylinder having a decided tendency to remain stationary. Another section of steel cylinder was attached to the loaded walls and lined with concrete, the structure being at this time about 6 inches out of level in the width. In this position the cylinder continued to settle slowly notwithstanding the efforts made to guide it to a level or plumb position. It was noted that the fine screened sand which had been placed between the sheathing and the cylinder shifted continually, causing the movable structure to be jammed far to one side, and on account of the shape of the excavation (round) and the impossibility of moving the sand guide at will, the space being too small, it was found to be impracticable to right the cylinder. The volume of water entering the excavation rapidly increased, and as the tide turned, the laborers were obliged to leave the bottom on account of the absence of pumps of sufficient capacity. At this time two 3-inch pulsometer pumps, assisted by a large single-cylinder Emerson pump, were in continuous operation, the depth of the excavation being about 25 feet below the surface of the park and about 5 feet below the low-water mark in Gloucester harbor. It was the intention of the contractor to complete the work without the use of compressed air, treating the ground through which the work was to be built with cement grout, this method being less expensive and having been used to advantage in other and similar work. Here, however, it was found that the nature of the gravel was such that the ground waters at all times moved freely through the ground, so that there was no opportunity at any time to leave grout in place for a sufficient period to allow of its attaining the initial set. Therefore, on May 2, the contractor decided to resort

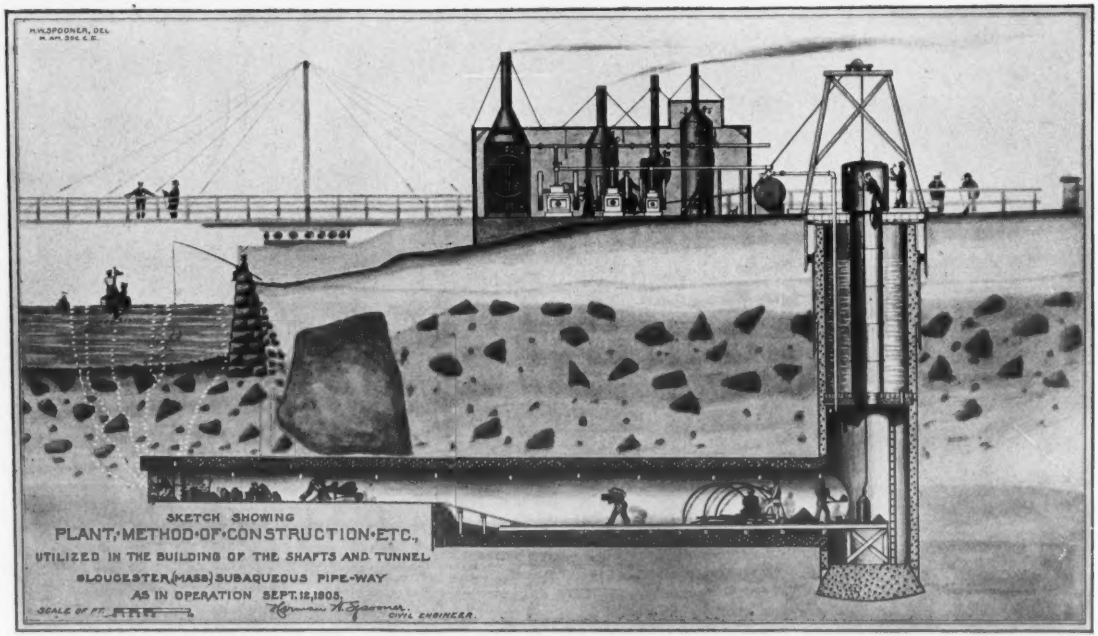
H.W.SPOONER, DEL.
M. AM. SOC. C.E.
SKETCH SHOWING
PLANT, METHOD OF CONSTRUCTION ETC.,
UTILIZED IN THE BUILDING OF THE SHAFTS AND TUNNEL
GLOUCESTER (MASS) SUBAQUEOUS PIPE-WAY
AS IN OPERATION SEPT. 12, 1903.
SCALE OF FT.
Herman H. Spooner.
CIVIL ENGINEER.

PLATE I.

PLANT AND METHOD OF CONSTRUCTION.

to the use of the pneumatic method of construction. At this time the bottom or cutting edge of the cylinder was about 7 feet below low-water mark, it being necessary to lower the structure about 20 feet further before the required depth was reached. During the next two days the cylinder was worried down to a bed consisting of very coarse, hard gravel and isolated boulders to a depth of 28 feet below the surface of the park.

A recess was cut in the concrete lining to receive the wooden deck which was to support the compressed air tube and lock, and work in the east shaft was abandoned until the apparatus, air compressor, additional boilers, receivers, etc., could be assembled.

The cylinders to be placed within the excavation on the west side of the canal were rolled across the drawbridge and placed in correct order inside the sheathing with the aid of shears, power being furnished from the plant on the east side of the canal. Before being placed in position, six skids or guides consisting of timber 4 by 6 inches in size were affixed by lag screws to the sheathing, being notched at each ring of channel-iron, this pattern of a guide being used in place of the screened sand used in the east shaft. The inside of this cylinder was treated in the same manner as was the one in the opposite shaft and the walls constructed of concrete, an air deck, 18 inches in thickness, being built into the walls as the work progressed. The materials encountered in excavating were nearly identical with those found in the east side except that strata of gravel mixed with iron through which the water entered freely were passed through.

The pumping apparatus was moved to the west shaft and an attempt made to work this cylinder to a greater depth than was reached in the east shaft, but when a level had been reached which was within a fraction of an inch of the level of the bottom of the first shaft, the contractor was forced to abandon operations and wait for the application of compressed air.

While work was being carried forward on the westerly side of the canal, a small compresser with a receiver had been installed near the derrick on the east side of the canal, and on May 27 the air-lock and tubing especially designed and built for this work arrived and were ready, together with the head-house, and in operation, four days thereafter. Previous to this time there had

been very little continuous work, and as when using the pneumatic method there is a continuous expense to maintain a dry excavation, two shifts were organized. The day shift was in charge of the foreman, Mr. Charles B. Lewis, the other, or night shift, being placed in charge of Mr. Russell. Each shift worked eleven hours and consisted of foreman, stationary engineer, fireman, locktenders, miners, tenders, and muckers, generally eleven men being employed during each shift. The men employed upon this work were of the first rank in their several vocations, exercising great care in the performance of the duties assigned to them, and on this account, if for no other reason, the writer is pleased to be able to state that there were no men injured during the execution of this contract, and the final result is entirely satisfactory.

The air compressor was in operation thereafter continually until the work was nearly completed. All materials were removed, and all materials required in construction were transferred, through the air-lock, thus increasing the cost of construction nearly fourfold.

The cylinder was bound in such a manner that although the gravel was excavated from beneath the cylinder to a depth of 3 feet and additional weight was added in the form of water on the deck and piles of brick upon the rim, it did not drop until all the air-pressure had been removed and the earth at the sides of the cylinder commenced to heave inward. This passage of gravel or "heave" from around the cylinder and about the sheathing down and into the void excavated and into which it was desired to drop the structure caused trouble throughout the entire lowering of this shaft, also until the tunnel was completed about 10 feet from the side or eye. Often after working for an entire shift, when air pressure was removed, a net gain in depth of only 1 foot was made, while at other times only 3 inches were gained.

Poling boards were used beneath and in the rear of the cutting edge to hold back the material which had a decided tendency to heave, but with little effect. In some instances over 4 feet of sand and gravel rushed in when the pressure was removed, requiring nearly an entire shift of work to remove it.

In order to increase the weight of the cylinder, hundreds of tons

of pig-iron were placed upon the deck and walls in the endeavor to drive the cylinder down, but even under this added weight it still remained firm.

The sand used as a guide had shifted and the surrounding ground settled or slumped, carrying sheathing and channel-iron rings with it to such an extent that the head-house was unstable, a cavity extending nearly 10 feet from the cylinder in all directions being open. Heavy timbers were placed to span the hole and support the superstructure, being held together with heavy chains.

It was decided at this time to drive a square set of sheathing outside the circular set originally placed, in an attempt to reach the channel-iron rings which were evidently jammed between the steel cylinder and the original sheathing; also to support the earth and prevent further caving. This was accomplished with considerable difficulty, it being found that the rings were in close contact with the cylinder, being much lower on one side of the cylinder than on the other; also that the heads of a few of the rivets used in making the joints of the cylinder had been entirely cut or scraped off as it had slid through the ring. Two rings were cut and the accessible portions removed, after which a boulder that had slid in and bound against the cylinder was broken and removed.

The work of excavating was recommenced beneath the cylinder after sections of the tube leading from the air-lock to the deck had been placed in position, and the cylinder was lowered after continued and discouraging efforts, as at no one trial did it go down more than 20 inches.

Grade lines were drawn across the cylinder on June 23 and preparations made for a final drop to the required grade. After the air pressure was removed the structure settled gradually, and when the desired point was reached, the air pressure was applied, but before there was sufficient pressure to counteract the weight, it had settled nearly 1 foot below the line.

A space was immediately excavated below the cutting edge and poling boards placed in such a position as to allow for the placing of a concrete foundation of much larger diameter than the cylinder. The center of the excavation was dished to a depth of 8 inches below the sides or ends of the poling boards, the material at the bottom and upon which the foundation was placed consisting of a mixture

of coarse and fine hardpan gravel, in which, on account of its firmness, it was difficult to make an impression with a pick.

A pressure of 17 pounds per square inch was maintained while depositing the concrete for the foundation, placing the waterproofing, and until the whole mass had firmly set; the cavity around the shaft was filled and preparations made to extend the walls of the shaft upward.

The power plant upon this work July 1 consisted of three boilers, including the one used in connection with the hoisting engine, all being piped together and making a total of fifty horse-power to operate the hoisting engine and compressor. At this time it was decided to make a trial of the use of cement grout to harden the ground through which the tunnel was to be driven. A small 2-inch opening was made in the steel cylinder in the upper part of the eye 12 feet in diameter, which had been left free from concrete when the walls were formed, a thin mixture of grout was prepared and an attempt made to force it into the sand and gravel surrounding the steel casing, but after several attempts the idea was abandoned, as it seemed, under existing conditions, impracticable, it being only possible to solidify a very small section of the material directly surrounding the delivery point of the grout.

As the excavation was progressing at the different levels, corresponding to those through which the tunnel was to be driven, careful examination was made, with the result that when it was found that the solidification method was impracticable, recourse was had to the original method of using steel plates to support the earth above and upon the sides of the tunnel, while the masonry walls were placed with the aid of compressed air. A supplementary agreement was drawn and the contractor granted permission therein to use steel plates in place of ring timber provided that the masonry walls, including the waterproofing and plaster, were constructed to a minimum thickness of 18 inches, a thickness equal to the proposed ring-timber and brick wall. This agreement was signed, plates ordered, and preparation made to cut out the eye. On July 3 a 50 horse-power upright boiler was added to the existing plant. The work of cutting the steel cylinder progressed very slowly on account of the disadvantages under which the men labored, the positions necessarily occupied in

holding and striking the points being decidedly awkward. After about 170 hours of continuous work by entire shifts with diamond points, a part of the upper portion of the eye was removed and it became evident that the channel-iron rings which were mentioned as having been used as a support for the original sheathing were to continue to disturb operations. Directly across the opening made in the side of the cylinder two of the rings were found twisted completely around each other, having been carried down at least 18 feet while in close contact with the cylinder, thus causing friction which retarded the settling of the cylinder. The sections of rings spanning the eye were cut out and the excavation continued.

As there was no clay encountered in this work, the necessary amount of clay was hauled from the location of an old clay pit near the corner of Bond Street and Western Avenue, a distance of about 800 yards. This clay was not of the best quality for this work but was as good as could be readily procured, the disadvantage in its use being that upon application to the gravel breast and plate-joints it dried, causing crevices to immediately appear through which the air freely issued; consequently, it was necessary to keep men continually employed dampening and renewing the clayed surface.

On July 12 the need of an addition to the air compressor plant was noted, as the small high-pressure engine delivering about 300 cubic feet of air per minute seemed to be inadequate, the temperature in the heading rising to such a degree that an effort was made to cool the air with water and ice previous to sending it into work, and thus enable the men to work freely. The opening in the top of the eye was only 18 inches in depth at this time, and on account of the loose nature of the ground the single compressor was working to its full capacity in order to maintain sufficient pressure to keep the water away from the breast.

A few small boulders were encountered in this first opening, which were removed without difficulty. For four full days, or eight shifts, the men labored in excessive heat, depending upon the one compressor, and succeeded in driving the arch of the tunnel a distance of four plates, or 4 feet from the side of the vertical shaft. After two more rings were added it was decided to

suspend operations and seal the heading with clay until another compressor could be installed, as it was decidedly dangerous to excavate further and depend on the one compressor then operating at its full capacity to maintain the required pressure.

On July 22 another high-pressure compressor capable of delivering about 800 cubic feet of air per minute was installed and in operation, working in conjunction with the other, and the work was again rushed forward.

The contractors at this time realized the necessity of still further increasing the plant by the addition of another boiler, as the three small boilers on the work were taxed nearly to their entire capacity. When the arch had been driven a distance of 8 feet the needle-beam, consisting of a timber 10 feet in length, 12 inches square, was placed in position, and the work of removing the lower half of the eye of the cylinder was commenced. The plate-joints and breast were completely covered with successive coatings of clay to hold the air, and even then it required the operations of both compressors at a high speed to maintain sufficient pressure, the thermometer registering 100 degrees in the heading and 90 degrees in the lock. The continuous labor (eleven hours) in humid compressed air at such high temperature began to affect the laborers and they were obliged to come out through the lock at intervals for change of air. On July 27 the brick masons laid the first section of invert and completed the arch and work around the eye on July 29, laboring in the intense heat nearly forty-five hours to complete the section 6 feet in length.

A temporary bulkhead of plank and bags of clay was placed in the invert at the end of the completed section, and the heading again opened. While this work had been progressing, another boiler (capacity 150 horse-power) had arrived, the entire plant being connected and in working order on August 3; the heading had now been extended a distance of 12 feet through coarse gravel and boulders. At this time the larger of the two compressors became jammed and was out of commission for a few minutes, the whole load resting on the small compressor. During the strain this compressor turned 140 revolutions per minute, and although the pressure gradually dropped, the single engine held sufficient pressure until the defect was repaired and both were running.

HEADING AND BENCH.

It was evident to the writer that there was not a sufficient duplication of plant upon the work, and in consequence he requested the contractors to still further add to the existing plant a compressor delivering at least 1100 cubic feet of air per minute. Under the conditions, it was unsafe to carry on operations in the heading, not only on account of the danger to the laborers, but also on account of the danger of loosening or the caving in of the breast and the loss of time in again recommencing operations.

On August 16, 26 feet of the walls of the tunnel had been completed, and the contractors had decided to send a third compressing engine to the works, had procured a large low-pressure machine, capacity 1100 cubic feet per minute, and assured the writer that it would be in operation within a few days.

At various times during the progress of the work, the Board of Water Commissioners viewed the work, passing the air-lock with slight difficulty. A few others who were perhaps especially interested in the nature of the work or the methods used, succeeded in reaching the lower levels under pressure, but the majority of the citizens preferred to keep at some distance from the works, being satisfied to inspect the men as they emerged from the outer door of the lock in a cloud of steam.

The contractors kept in touch with the work, and knowing well the delicacy of the operation of driving the tunnel through the coarse gravel and stray boulders that might be encountered, suggested a decided change in the method of construction. Under the bed of the canal the roof of the tunnel was to be constructed within 11 feet of low-water mark, the bed of the canal being practically dry at low tide. The amount of material above the work was deemed insufficient to hold sufficient pressure to allow for the construction of a full section of the tunnel wall; therefore it was decided that when the completed walls had been erected to within a safe distance of the canal, the upper half or arch should be driven and the arch wall completed under and as far as the westerly side of the canal to a point beneath the retaining wall.

The last addition to the plant consisted of a large low-pressure compressed air engine, having a capacity of 1100 cubic feet per minute, and was installed and in operation on August 23. It was found that the difference in the temperature in the tunnel was

about 20 degrees, being much lower than when the air was supplied by the small compressors; it was also noted that sufficient air could be supplied by the new engine and half speed on the second machine, allowing for repairs on the third or smallest engine.

The work hereafter progressed more rapidly, and on August 28 46 feet of the tunnel wall was completed, and on September 1 a gain of 10 feet additional had been made.

At a point about 56 feet from the easterly shaft a temporary bulkhead was erected, filling the bottom of the tunnel or invert to within a few inches of the spring line, composed of a brick wall 12 inches in thickness and backed by clay puddle. This dam or bulkhead remained in place until the arch walls were completed under and beneath the western walls of the canal. During the construction of this arch about 9½ pounds of pressure was sufficient to carry on the work. When the tunnel had been driven to a point within 20 feet of the easterly canal wall a slight leakage of air was noted in the waters passing through the canal. This disturbance continued to increase as the work was extended, and when it had progressed to a point directly beneath the canal, the air rushed up through the waters in such volume from the heading that the canal for its entire width and a distance of 50 feet up and down stream resembled a boiling caldron, which was watched with much interest and speculation by large numbers of people from the bridge.

This work of driving the arch had progressed only a few feet when a boulder was uncovered in the roof extending across the heading for a distance of 5 feet and hanging into the opening about 2 feet. A few light charges were fired in small hand-holes made on the under side of the boulder, but no marked effect was made. Drilling and splitting was then commenced, and after nearly a week of continuous work the roof-plates were made secure beneath the stone, a sufficient amount of the boulder having been removed. Several small boulders were found, split, and removed from the heading, remaining in the completed tunnel until the air deck was removed, as they were too large to move through the lock.

During the progress of this part of the work the ground occupying the position of the invert remained undisturbed, the bench or

HEADING. TUNNEL NEARLY COMPLETED. INVERT UNDER CONSTRUCTION.

PLATE III.

ground below the spring line being covered with a layer of clay 6 inches in thickness, having an overlayer of boards. It was quite a difficult task and required continuous watching to keep the pressure at an amount sufficient to keep the water from entering under and through the clay floor, and again not enough to lift the canal bottom and cause a blowout, it being necessary to watch the rise and fall of the tide and regulate the pressure according to its different levels.

During this part of the work the smallest error in air pressure could but result in severe monetary loss to the contractors and possibly the loss of the lives of the men employed in excavating the heading. The materials excavated were coarse sand and gravel, through which the air rushed freely when not retarded by the coating of clay applied from within, and was removed from its original position by small trowels. This gravel, after being dug out with the trowels and dropped on the bench, was shoveled into a single wheelbarrow and transferred to the shaft. Here it was again shoveled into a bucket to be lifted into the air lock. From the lock it was dumped in carts and hauled to the dump. Thus it will be understood that the gravel excavated was handled five different times before being finally dumped, making the expense heavy.

Several times during the perilous part of the work on the arch, the earth was driven upward by the air pressure or fell away, leaving a large aperture through which the air roared to the surface. During these periods the whole compressor plant was operated to its entire capacity; these voids were immediately filled with clay, bags, or any cloth or material which would stop the outrush of air, the miners knowing that were these voids not filled at once the pressure would relax and the waters from the canal and the harbor rush in. On September 21 the arch was completed to a point about 14 feet from the western shaft and beneath the westerly side wall of the canal, and a solid brick bulkhead erected. This bulkhead was built within the completed arch and about 1 foot back from the toothing, thus leaving sufficient brick work for connection with that part of the tunnel which was to be built from the westerly shaft.

The first temporary brick bulkhead was now removed and the

invert constructed, the connection between the arch and invert being made tight by splitting brick in form of a wedge and driving tight. This being neatly executed, the circular section was made complete to the terminus of the work to be accomplished from the east side. The bulkhead having been completed and braced by heavy raker timbers stepped into the brick invert, the air pressure was removed and the air tube and lock transferred and fastened in position in the west cylinder, the air and water supply pipes were suspended over the canal, the head-house placed in position, and the work of settling the western shaft commenced on October 6.

The west cylinder, having timber guides, settled rapidly, the cutting edge being kept in contact with the bottom, slipping down when the air pressure was slightly reduced; thus the trouble of the heaving of gravel, as was experienced in sinking the east shaft, was avoided, and on October 9, 12 feet of progress downward had been accomplished. On October 13 the cylinder reached the required level and the concrete walls were extended upward toward the surface. The excavation was made and foundation placed similar to that in the east shaft, and the work of cutting out the eye of the tunnel in the steel cylinder commenced. The levels and lines were transferred through the deck and preparations made to excavate for the arch. This work was commenced on October 19 and six days thereafter the toothing of the completed section and bulkhead was met, and on October 30 the continuous walls of the tunnel were complete from the east to the west shaft. The work of calking, cement washing, and finishing was begun immediately after the bulkhead was removed; the fires were drawn in the larger boiler and it was removed. On November 4 the night shift was discharged, the work thereafter being carried on by one gang during the day. Three days thereafter the air pressure was withdrawn, and the writer was gratified to note that there were very few damp spots throughout the entire length of the tunnel. Several small leaks appeared in the west shaft which were readily stopped when the air pressure was again in use.

The drains from the west shaft to the east shaft were laid, above which the ducts (six lines of six multiple vitrified duct) were laid

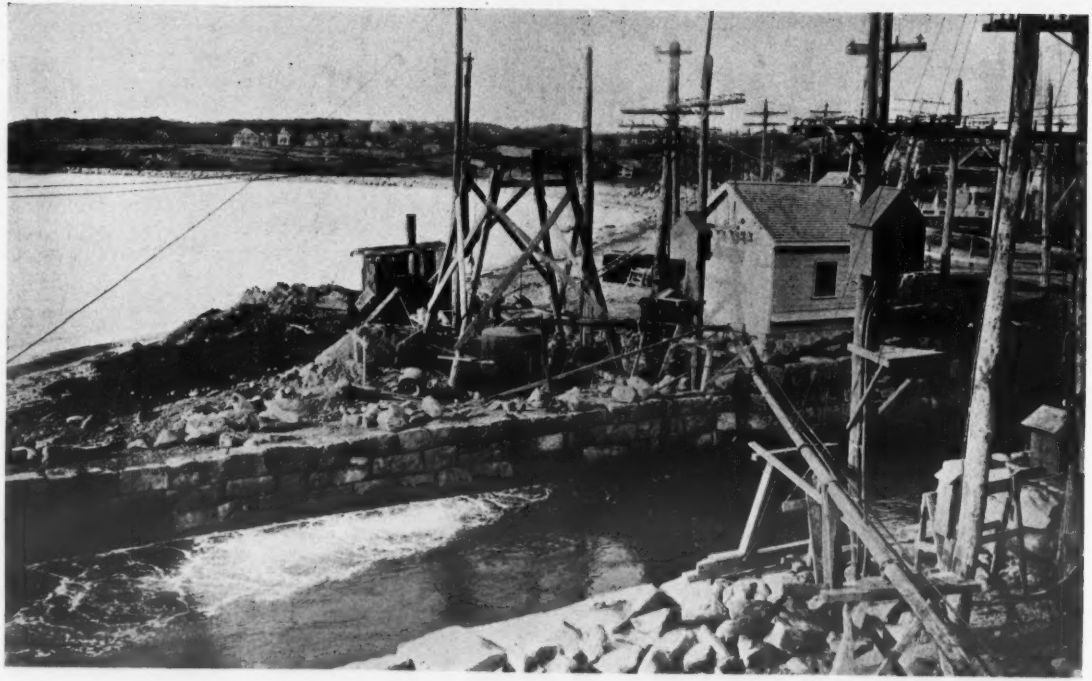

PLATE IV.

SITE OF TUNNEL, AND CONTRACTOR'S PLANT.
This view was taken when making the connection between the two headings.

in the invert or bottom of the tunnel, air pressure of 15 to 20 pounds per square inch being maintained until all were in place and covered with concrete. These six lines of duct were divided into two sections, being imbedded in the concrete, the joints waterproofed, and separated by a wall of concrete 1 foot in thickness, one side to be occupied by high tension, the other by low-tension cables; the concrete covering was overlaid with fine plaster, which serves as a floor.

The pneumatic pressure was finally removed on November 16 and members of the Water Board inspected the structure, together with the writer, and expressed satisfaction with the work, the total leakage being unusually slight.

The water mains, two lines of 20-inch cast-iron pipe, were next placed above the floor, supported upon brick piers on either side of the tunnel, the 12-inch gas main being supported in like manner in the center. These lines of pipe were extended up through that portion of the shafts designed for their occupancy, and the partition walls erected.

The ducts were wired, a line of wire extending from one shaft to the other through each duct to serve as a lead wire when placing the cables later.

The reinforced concrete roofs or covers were laid and the manhole caps and covers placed in position, the grounds around the shafts were graded, and the tools and machinery removed. The Board visited the tunnel on December 22, together with the writer, and after a thorough inspection, decided that the difficult task of building a practically waterproof tunnel and appurtenances under numerous disadvantages had been acceptably completed, and upon the following day the contractor was notified of the acceptance of the work.

The leakage of the tunnel and shafts is at this time much less than in any tunnel now completed in this country of which the writer has knowledge, being less than one-half gallon per minute, with evidence that this will be reduced in the future. When the material through which this work was built is considered, together with the several obstacles encountered, the contractor is to be congratulated upon the success of the undertaking and the fact that no person was injured during the work. The absence of

leakage in the brick walls of the tunnel is due in part to the excellent work of the two masons, George H. Eaton and Michael Ferriter, who laid up the walls under pressure and in extreme high temperature, and whose work, accomplished under the several difficulties, is certainly commendable.

To Mr. Charles B. Lewis, who acted as foreman in charge of the work for the contractors, is due the credit for close and unceasing care in the handling of all parts of the work, and of completing a wholly satisfactory piece of work.

The entire engineering work connected with this tunnel, viz., location, design, drafting of plans, including all general and detail plans, together with the drafting of the contracts, was executed by the writer in person, who also acted as resident engineer and inspector during construction, the only assistance required being furnished by the timekeeper and foreman employed by the contractor as per the terms of the contract.

A small vertical centrifugal pump was submerged at the bottom of the collection sump, being operated by an electric motor located directly beneath the roof of the shaft, the connection between pump and motor being made by a shaft bracketed to the side walls.

A float and automatic switch were included in the appurtenances to the pumping plant, and the water collected is of such small quantity that the automatic action of the pump occurs at intervals of fourteen days.

When the structure has been closed for a considerable time, moisture of condensation collects in the arch and upon the mains, which finally reaches the sump, but when the manhole covers are removed and a strong draught is allowed to circulate for an hour, the walls of the tunnel and shafts are sufficiently dry to allow the lighting of matches on the cement-washed surfaces.

Electric cables have been installed in the ducts, the gas and water mains have been in constant use practically since the acceptance of the work, and no trouble has as yet been noted; hence the practicability of a small sub-aqueous tunnel for the location of water and gas mains together with electric cables has been demonstrated to our entire satisfaction.

Completed Tunnel.

Plate V.

A CITY'S RIGHT TO METER PRIVATE FIRE SERVICES.

SHAW STOCKING COMPANY *v.* CITY OF LOWELL.

Supreme Judicial Court, Massachusetts, Middlesex, May 22, 1908.
(85 Northeastern Reporter, 90.)

SHELDON, J. We see no reason to doubt the authority of the water board of the defendant city to make the regulations here in question. These regulations require that all water supplies from the city's mains to the premises of any water-taker for the purposes of a private fire system shall pass through a meter, and that this meter shall be furnished and set by the city at the expense of the owner of the premises served.

Authority to supply water to its citizens was first given to the city of Lowell by Stat. 1855, Chap. 435. The third section of this act empowered the city, among other things, to construct and maintain proper aqueducts and pipes, to establish public hydrants, to prescribe the purposes for which they should be used, and to change or discontinue the same; to distribute the water throughout the city and to regulate the use of said water, and establish and collect the prices to be paid therefor, and also to do any other acts or things necessary or convenient and proper for carrying out the provisions of the act. Additional statutes have since been passed, but the power and authority of the city have not been diminished by any of them. See Stat. 1866, Chap. 200; 1869, Chap. 351; 1870, Chap. 321; 1893, Chap. 412; 1895, Chap. 247.

By Chapter 45 of the Revised Ordinances of Lowell, the powers thus given the city have been vested in its water board, in pursuance of the permission given by Stat. 1855, Chap. 435, Sect. 5.

The defendant has not required and does not purpose to require in future any payment for water used in extinguishing fires. The principal object of the defendant's water board in requiring fire-service pipes to be metered is to prevent the surreptitious or careless withdrawal of water through such pipes for other purposes than the extinguishment of fires; another object is to procure the

measurement by meter of all water consumed for any purpose in order to check wastage and to require each taker to pay for the exact quantity of water furnished to him. The requirement is well adapted to aid in accomplishing these objects; and this is none the less so, although its operation sometimes may be circumvented by some fraudulent device. The regulation must be regarded as reasonable unless some of the plaintiff's specific objections to it can be sustained.

The plaintiff contends that it ought not to be required to pay for the meter to be applied to its private fire service pipes. Its counsel relies upon the decisions in Red Star Steamship Company *v.* Jersey City, 45 N. J. L. 246; Albert *v.* Davis, 49 Neb. 579; Smith *v.* Birmingham Water Works Company, 104 Ala. 315; Spring Valley Water Works *v.* San Francisco, 82 Cal. 286, 316; and Sheffield Water Works *v.* Carter, 8 Q. B. D. 632. But these cases differ from the case at bar. They generally turned upon the language of the statutes under which they arose, or the provisions of the contracts which were before the courts. In this case it has been found by the court below, with evident correctness, that the defendant is under no legal obligation, by contract or otherwise, to furnish the plaintiff with water for its private fire-service system. Under the present circumstances, we prefer, so far as it is a matter of precedent, to follow the carefully reasoned opinions in Sheffield Water Works *v.* Bingham, 23 Ch. D. 443, in which the earlier case of Sheffield Water Works *v.* Carter, *ubi supra*, is fully discussed; and State *v.* Gosnell, 116 Wis. 606, decided in 1903, in which the earlier decisions are reviewed. Both upon principle and authority we are of opinion that under circumstances like those before us it is not unreasonable to require the installation of a meter at the plaintiff's own expense in its private fire-service pipes.

Nor can it be said that this regulation imposes undue burden upon the plaintiff. The defendant has afforded reasonable means of extinguishing fires by public hydrants; if the plaintiff desires in addition a private system for the protection of its own buildings, it is not unfair for the defendant to impose, as a condition of supplying without other charge water to make this system available, the requirement that the plaintiff shall take this water only through a meter to be put in at the plaintiff's expense. The defendant's

duty to supply water at reasonable rates to all takers without discrimination, so far as this duty exists (see Merrimack River Savings Bank *v.* Lowell, 152 Mass. 556, and Lombard *v.* Stearns, 4 Cush. 60), does not carry with it any obligation to supply water free of charge for the plaintiff's private system of safeguarding its property.

Nor has there been unjust discrimination against the plaintiff in the enforcement of this regulation. The rule is a general one, applicable to all persons who maintain a like private system. That it has been put in force only gradually, beginning with the worst or the most important cases, affords no reason for enjoining its enforcement in any particular case. Parker *v.* Boston, 1 Allen, 361. Ladd *v.* Boston, 170 Mass. 332. Wagner *v.* Rock Island, 146 Ill. 139.

Accordingly, the decree of the Superior Court dismissing the bill must be affirmed; and it is

So ordered.

METERS AND WATER CONSUMPTION OF THE HARTFORD WATER WORKS.

BY ERMON M. PECK, ENGINEER IN CHARGE OF MECHANICAL DEPARTMENT, HARTFORD, CONN.

[Read September 24, 1908.]

When the big new Tumble Down Brook Reservoir was completed in 1895 it was predicted confidently by many wiseacres that Hartford would not need another reservoir for many years to come. The population of the city at that time was about 66 500.

In December, 1899, only a little more than four years later, with a population of about 80 000, or only about 13 500 greater, the city suddenly found itself confronted by one of the worst water famines in its history. To produce this condition of affairs two factors were dominant, viz., unfavorable occurrence of rainfall and consumption greatly in excess of its needs. In this exigency the hustle gong was sounded for the construction department and in record-breaking time, pumps, boilers, intake, and a new force main were installed only to "die a-bornin'"; for, with all the irony of fate, on the very day upon which the new plant was to be tested, Jupiter Pluvius deluged the earth, and Hartford's latest water famine passed into history. In the meantime, however, for several weeks the decrepit old pumping plant which had been used to supply the city from the Connecticut River nearly half a century before had been started into action and limped along until one morning, crystallized from many years of overstraining, the piston rod of its engine broke and the fortune of the Hartford Water Department looked darker than ever. The Hartford Street Railway Company was our good angel in this dilemma, and its general manager very kindly furnished and installed a motor to operate the pumps, so that in a few hours we were able to force filthy Connecticut River water into our mains with as much gusto as formerly, and continued to do so until the occurrence of the storm noted above.

When the drought was broken and our nervous system was

relieved of the temporary strain it was evident that something must be done.

The department had two inspectors who regularly covered the city twice per year on the assessment plan, and while these men knew that many leaks existed and that gross abuse prevailed along the line of permitting faucets to run to prevent freezing of pipes in very cold weather, their duties were too arduous to allow them to make detailed inspection for the purpose of detecting these sources of waste. Accordingly, 10 additional inspectors, one for each ward, were employed, who shortly gave good accounts of themselves by the number of premises where water waste occurred which they reported. These reports, coupled with the recent shortage, spurred the board of water commissioners on to adopt the policy of general metering of service pipes. It was planned to complete metering the city in about three years, and this was very nearly accomplished.

The following table is an exhibit of the number of meters in use and the daily per capita consumption by years. The 84.6 gallons per capita opposite the year 1900 may be taken as the best information we have of the per capita consumption previous to general metering, and was computed from scattering Venturi meter readings. In 1902 the automatic register was attached to the Venturi and since that time the records are reliable.

Year.	No. of Services in Use.	No. of Meters in Use.	Per Capita Consumption, Gals. per Day.
1900	8 951	550	84.6
1901	9 256	2 783	76.3
1902	9 514	6 993	78.8
1903	9 683	9 156	75.0
1904	9 809	9 604	66.7
1905	10 006	9 860	62.6
1906	10 328	10 137	61.6
1907	10 623	10 433	59.1

These figures are based upon the total population supplied, which at present is estimated to be divided as follows:

Estimate of population in Geer's 1907 Hartford Directory	106 000
Population supplied in the towns of West Hartford, Wethersfield, and Bloomfield	3 000
Floating population, equivalent to regular consumers	4 000
	113 000

The estimate of the floating population was arrived at by stationing observers at the outskirts of the city on the various trolley lines to count the passengers bound cityward. Similarly observers were placed at the Union Railroad Station. Each "floater" was estimated as one-third regular consumer.

At the present time the department has 10 922 services and 10 814 meters, 99 per cent. of the taps being metered. This is a high percentage compared with that of most other cities.

It should be said in this connection that the above reduction in the consumption of water has not been accomplished by meters alone, but partially by a rigid waste and leak inspection which has gone hand in hand with it. Inside the premises the inspection has been prosecuted by the meter readers. In the streets the water mains, services, hydrants, etc., have been inspected regularly by parties of men who did nothing else. The early experiences of this leak survey party were marked by the discovery of many leaks, some large and of long standing. The leak survey was established in 1902, but did not operate extensively until 1904. The large drop in consumption for that year I consider largely due to its work.

The rise in consumption in 1902 I consider due to the fact that the "big bill bogey," always easily conjured by the excited mind of the water taker, had failed to materialize, and the reaction towards increased consumption usually noted in such cases had set in. This, of course, was cut down in the succeeding years by fighting waste and leaks.

In this connection I may say that a very interesting computation was made during the past year, designed to show the proportion of the water passing the Venturi meter at the distributing reservoir which could be accounted for. After making proper allowances for unmetered water and under-registration of meters, it was found that only 16 per cent. of the water as registered by the Venturi remained unaccounted for. Since that time several of our fire service pipes have been metered, with the result that this percentage could be somewhat reduced.

Recently the board of water commissioners has become impressed with the importance of systematic tests in order to keep the meters within permissible limits of registration. We require

all meters to test not lower than 98 per cent. and not more than 100 per cent. on full flow.

All new $\frac{5}{8}$-inch, $\frac{3}{4}$-inch, and 1-inch meters are required to register 75 per cent. on a $\frac{1}{32}$-inch stream under the pressure at our testing bench, which would be equivalent to a flow of .0230 cubic feet per minute, and after they have been in service they are required to register on this flow. It is the intention to test all meters at least once in four years, and perhaps oftener.

Meters larger than 1 inch are required to test more in accordance with the service for which they are used than by a fixed rule, although, as a general proposition, $1\frac{1}{2}$-inch and 2-inch meters, after being in service, are required to register 50 per cent. on a $\frac{1}{16}$-inch stream, — a flow of about .113 cubic feet per minute, — the other requirements being the same as for smaller meters. The larger part of the meters above 2 inches in size are being fitted out to be tested in place. This is done by putting a valve in front of the meter with a hose connection between the two. To test the meter, the valve on the service is closed and the hose connected up with an accurate meter in series with the one to be tested as in the following sketch. (Fig. 1.)

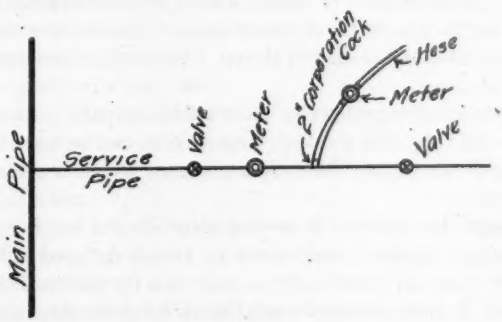

FIG. 1.

In laying new services the following plan has been adopted (see Fig. 2): *A* is a valve on a by-pass around meter. This valve is closed and locked at all times excepting when meter is being tested.

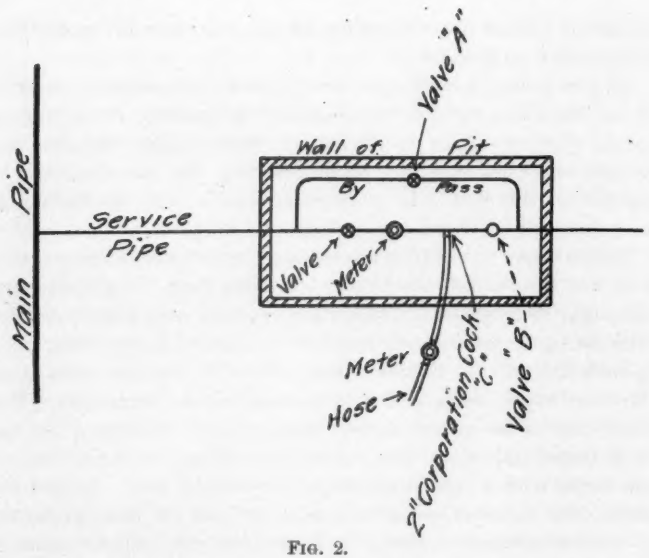

FIG. 2.

B is a valve in front of meter, and *C* is a corporation cock for connecting up hose with accurate meter. To test meter, hose is connected up as in the sketch above. Valve *A* is then opened and valve *B* is closed.

The whole arrangement of valves and by-pass is placed in a concrete pit. By this method, large meters can be tested without shutting off the supply from the consumer, which is often a great consideration.

Although this method of testing large meters has been in use for some time in other cities, it has not been employed in Hartford any more than experimentally to ascertain its practicability until recently. A party of men was at work for some time during the past winter fitting up the larger services for these tests.

It is our intention to test all the meters so arranged at least once each year, and in some cases twice.

The meter card which has been lately designed for the Hartford Water Board, is a large one, being approximately 9 inches by 14 inches. It is ruled and printed on both sides, one side being

devoted to information regarding installation and the other to maintenance. An 18-inch Elliott-Fisher billing machine is used for writing up the cards.

The writer may add that the card system has been adopted recently for the meter readers' books, and these, too, are written upon this machine.

DISCUSSION.

MR. ALLEN HAZEN.* I should like to ask Mr. Peck if he has ever made a calculation of the amount of water used for manufacturing purposes that is drawn from other sources than the supply pipes. That is, of itself, a very important matter, and I know that in Hartford a great deal of water is drawn from the streams for manufacturing purposes, in addition to what comes from the public supply; and wherever the per capita consumption is stated, I think that it is important to have go with it a record or statement of what the conditions of the use of manufacturing water are.

MR. PECK. That is a question which came up about a week before the meeting, but we had no means of answering it. We are liable to have to make some estimate of it before a great while, but at present I cannot give it. It is a large amount of water; there is no question about that.

MR. HAZEN. The factories draw the greater part of their water from other sources than your supply; that is true, isn't it?

MR. PECK. Some of them do, not all of them; I would say a large part of them.

MR. M. N. BAKER.† Has there been any material change since you began metering in the amount that manufacturers take from other sources?

MR. PECK. No, I do not think so. I do not think it has been affected at all by putting on meters.

MR. H. N. PARKER.‡ I should like to ask why you took the consumption of the floating population as one third. Is that

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* Of Hazen & Whipple, Consulting Engineers, New York City.
† Associate Editor *Engineering News*, New York City.
‡ Assistant Hydrographer, United States Geological Survey, Washington, D. C.

based on any estimate of time that a visitor to the town was likely to stay there, or what reason was there for using that figure?

MR. PECK. That is just what I based it upon. I tried to hit upon some scheme for fixing a value for the "floaters," and I arrived at it in that way, by considerng, perhaps, that the proportion of the water they would use would correspond with the time spent in the city.

THE PRESIDENT. Perhaps it might be interesting if Mr. Peck would tell us whether he is using many detector meters on the fire services, or how he meters those.

MR. PECK. We have a few detector meters in use.

METER RATES.

BY WALTER H. RICHARDS, ENGINEER AND SUPERINTENDENT, WATER AND SEWER DEPARTMENT, NEW LONDON, CONN.

[*Read September 24, 1908.*]

The subject of meter rates has been much discussed, both in this Association and others, but a few points remain to be brought out in an otherwise threadbare subject, and it is with this in view that this paper is introduced.

Up to this time meters have been installed primarily to prevent waste, and there is no doubt that in this particular the meter is successful. But as was so clearly shown in Mr. Johnson's able paper,* the per capita use is constantly on the increase, due to the legitimate consumption through an increased number of fixtures and from other causes. The per capita consumption varies considerably with the character and habits of the population; for instance, Woonsocket, with 91 per cent. of its services metered, has a per capita consumption of 29 gallons per day, while Newton, with 86 per cent. of its services metered, has a per capita consumption of 54 gallons.

But is it not time that we plead for measured water on the ground of equity? Why should any intelligent engineer of water works undertake to defend the so-called schedule rates which, if he is well informed, he knows to be full of inconsistencies?

If it is argued that it costs no more to procure and deliver two gallons than one, the argument fails when we apply it to larger quantities, as it often costs as much to increase the supply to a city by 100 per cent. as the amount expended for the original work.

If the installation of meters is deferred on the grounds of economy, it is clearly a subterfuge, and an injustice is resorted to, to save the cost of the necessary machinery to "deliver the goods," for the meters are undoubtedly a part of the water-works plant. To say that all stores, markets, or barber shops use like quantities,

* JOURNAL N. E. WATER WORKS ASSOCIATION, Vol. 21, p. 109.

or even that any two use like quantities, is absurd. To charge for the supply of one fixture the same as another, regardless of the number of times it is used or the length of time it is used, is clearly neither scientific or equitable. The use of meters has demonstrated that one party may use double the quantity of water that another does under precisely the same conditions, and even were this not true, the constantly increased number of uses to which water is put renders the formulation of a schedule rate for each kind and each size of fixture used by a different number of persons for different purposes entirely impracticable. Water should be sold, therefore, like other commodities, according to the weight or volume.

The charge for water, like any other commodity, should be based on its cost, and as the cost is different in different places, it follows that the rate should be different, and if the water department were conducted on an independent and on a business basis, that rate should not be below cost.

The cost of water in various cities, as shown in the following table, is obtained by dividing the total cost of maintenance and repairs, including interest on bonds,* by the total amount of water flowing into the city. This table shows great variation, the price varying from 1.8 to 0.27 cents per thousand gallons. As in some cases, however, a considerable portion of the cost of the works has been paid from the income, it is a question whether this method can be fairly used to ascertain the cost of the water; it would seem right to calculate interest on the net cost of the works; furthermore, it has been found that about 40 per cent. of the water going into a city is lost by leakage or from undiscovered wastage before reaching the consumer; hence only 60 per cent. of the entire flow should be considered.

ACTUAL COST OF WATER PER THOUSAND GALLONS SUPPLIED.

Atlantic City, N. J.	$0.0723
Battle Creek, Mich.	.072
Bay City, Mich.	.0315
Billerica, Mass.	.1768
Cambridge, Mass.	.0659

* JOURNAL N. E. WATER WORKS ASSOCIATION, Vol. 19.

Chelsea, Mass.	$0.0442
Cleveland, Ohio	.0232
Haverhill, Mass.	.04
Lawrence, Mass.	.089
Lowell, Mass.	.1667
Lynn, Mass.	.10
Marlboro, Mass.	.1345
New Bedford, Mass.	.047
New London, Conn.	.0546
Oberlin, Ohio	.1153
Reading, Mass.	.27
Reading, Penn.	.018
Taunton, Mass.	.0983
Waltham, Mass.	.0637
Westerly, R. I.	.0878
Winchendon, Mass.	.2302
Woonsocket, R. I.	.1342

The problem, therefore, is to find the cost of water which can be delivered to customers without additional main works, from which the rate should be fixed so as to furnish, with other rates and charges, a sufficient income to provide for the payment of all interest charges and the maintenance of the works, together with such unforeseen expenditures as may be required for small extensions or additions to the works, and for expenditures due to accidents which cannot be foreseen.

A large percentage of the cost of the works is due to the increased size of the mains, fire hydrants, etc., which are necessary for fire protection, and which are for the benefit of the general taxpayer. Water for schools and public institutions is in the same category, and all this should be paid for from the tax rate. Other than the above, the taxpayer, as such, should have but a small part of the expense of maintenance of the water system.

So far as extensions of mains is concerned, after the main portion of the city has been piped, it may be provided for by the guarantee in water rates, on the part of abutting property, of a reasonable percentage on the cost of a small main of size sufficient to supply that street (say 6-inch) until such time as the regular rates amount to this guarantee.

The cost of the meter itself and the cost of setting the same must be provided for and should be a charge on each meter

sufficiently large to pay cost of repairs due to wear and breakage from frost and for renewals after the meter is worn out. Very few data are available on this subject. A charge of 10 per cent. on the cost is the rule at present, which is probably too small. The practice in some cities of charging the cost of meter and repairs to the consumer does not appear to be desirable, as the meter is a part of the water-works system and should be always under the control of the department, and to charge the cost to the consumer is simply another way of increasing the expense of the water to the consumer.

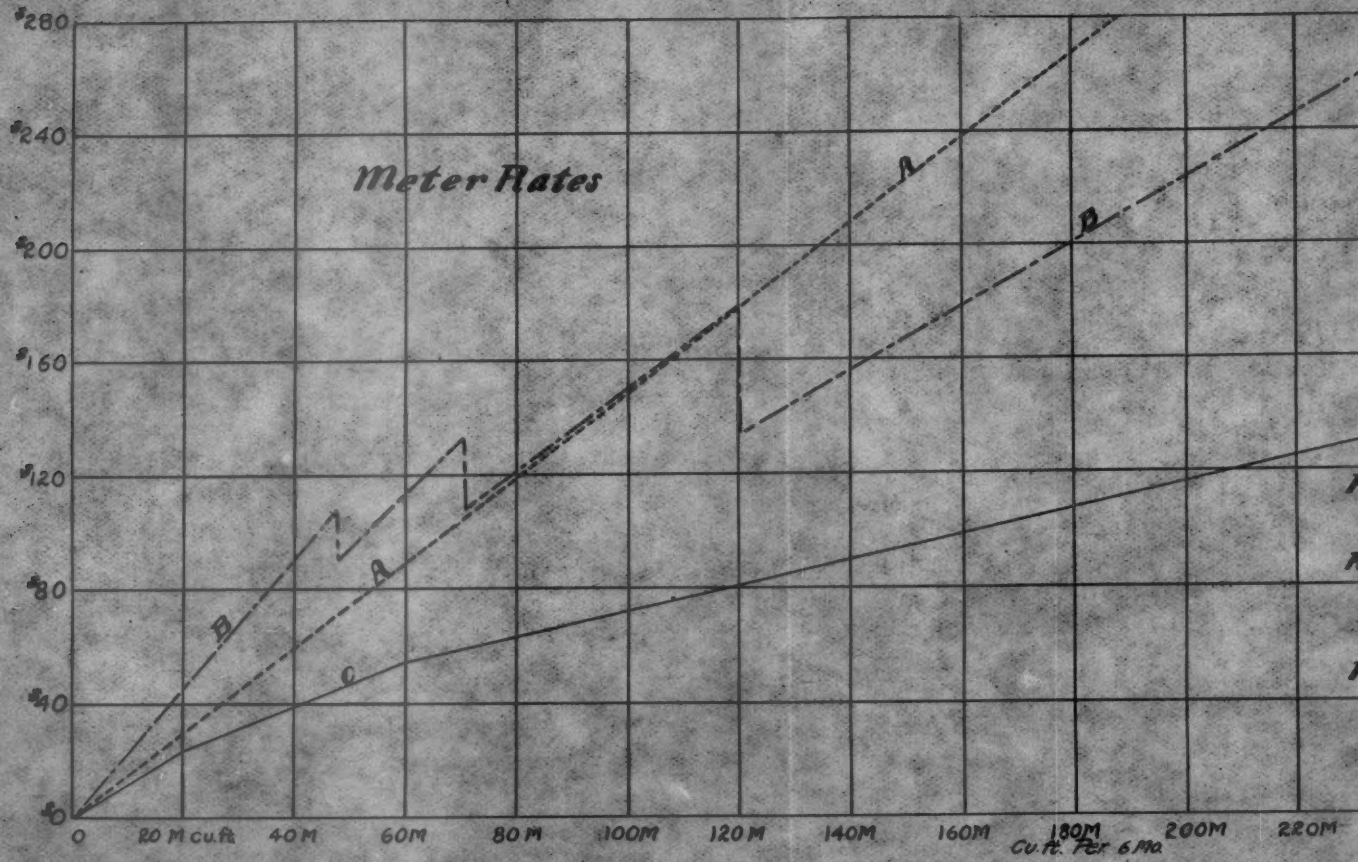
A uniform charge for all water without regard to the quantity or purpose for which it is used has been suggested, but it should be considered that a considerable portion of the expense of securing the purity of the water is to fit it for domestic use; and further, it costs but little more for service pipe and meter for a large quantity than a small quantity. For instance, a 2-inch service can easily supply as much water as twenty ordinary $\frac{5}{8}$-inch services, whereas the cost of the service is but about ten dollars more than the $\frac{5}{8}$-inch service.

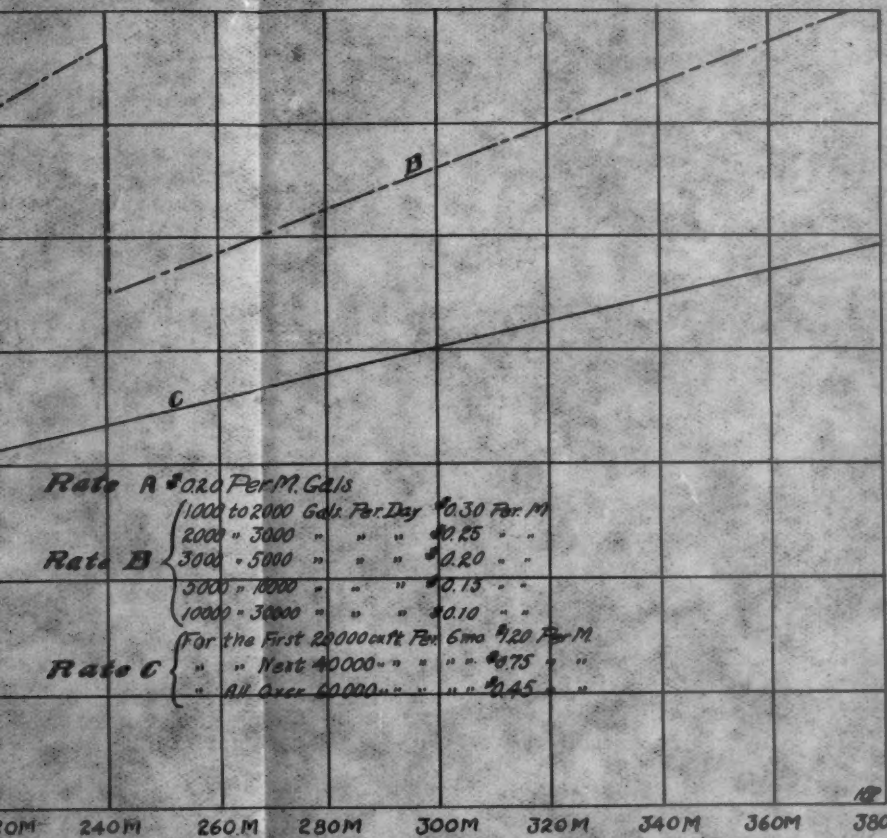
To cover the cost of connecting with the mains, and other costs which are uniform regardless of the quantity of water used, a minimum rate is desirable. The practice seems to vary between $5 and $10 per annum. The low rate seems to be desirable as encouraging the use of meters.

The formula suggested, then, is: Divide the cost of maintenance, repairs, renewals, and interest on cost of works less that cost necessitated by the fire supply, by the quantity of water the works will supply less the leakage from mains (say 50 per cent.).

To this should be added a constant for unforeseen expenses due to accidents and for such extensions of mains as do not increase the capacity of the works.

From the above it is evident that no comparison should be made between the rates in different cities, and, as a matter of fact, there is a wide difference in meter rates. Few, however, seem to have rates fixed on a scientific basis, and many contain glaring inconsistencies. This is illustrated by the rate which charges one rate for a certain amount used in a given time and a smaller rate if a larger amount is used in the same time, by which a customer,


Meter Rates
$280
$240
$200
$160
$120
$80
$40
$0
0
20 M cu.ft.
40 M
60M
80 M
100M
120 M
140M
160M
180M
200M
220M
Cu. Ft. Per 6 Mo
A
B
B
A
C


B
C
Rate A $0.20 Per M. Gals
Rate B
1000 to 2000 Gals. Per Day $0.30 Per M
2000 " 3000 " " " $0.25 " "
3000 " 5000 " " " $0.20 " "
5000 " 10000 " " " $0.15 " "
10000 " 30000 " " " $0.10 " "
Rate C
For the First 20000 cu ft Per 6 mo $1.20 Per M
" " Next 40000 " " " " $0.75 " "
" All Over 60000 " " " " $0.45 " "
240M
260M
280M
300M
320M
340M
360M
380M

having used a certain amount, finds he will save money to let his water run. This is sometimes supplemented by an addition to the rule by which, between certain quantities, the same amount is paid.

These forms of rates are illustrated by the diagram, Plate I, "A" being the straight rate, "B" being the rate whereby a consumer gets more water for less money, and "C" being the gradually decreasing rate which gives a parabolic curve. All the curves are illustrations of rates now in use.

No water department manager need think that having decided on the rate his troubles are over, for a host of difficulties arise with every meter set.

How many meters shall be set in a building? If the department sets but one meter on a service pipe, how is the landlord to divide the charge among his tenants? If he is compelled to have a meter for each tenant, who furnishes, sets, and reads these meters? And if the rate is a decreasing rate billed to the landlord, how shall it be divided among the tenants? If the water department reads the meters, shall the department divide and bill to each tenant?

With a decreasing rate, shall the bill be calculated for each service pipe metered or all the service pipe in the building combined, or all adjoining buildings combined owned by the same owner, or all the buildings or supplies in the city owned by the same owner?

It seems best to the writer for the department to furnish, set, and read one meter for each service pipe and let the landlord divide it among tenants as he sees fit.

Where meters are required for certain uses only, shall the meter be set so as to meter all or a part of the building supplied?

While it seems absurd to have the fixtures in one room metered and those in the next room unmetered, these are conditions existing in the writer's own department.

Whether a meter should be set inside a building, in the sidewalk, or on the lawn is a question. To set meters in the sidewalk or lawn increases the expense of setting largely, but avoids danger of freezing and measures all water entering the premises; on the other hand, if set inside the building it is more easily read, especially in cold weather, and can be kept track of by the consumer.

When it is suddenly decided to meter a certain class of consumers, leaving the remaining consumers to pay schedule rates, much friction arises and the installation is made with difficulty, and, in the writer's opinion, it is much fairer and the rule is enforced with less objection on the part of consumers if all supplies are metered without exception.

In presenting this paper no attempt has been made to indicate an exact rule for calculating a meter rate or the charges for meters, but the rule is presented as a guide, each department to be guided by local circumstances. The writer's preference, however, is for a graduated rate as indicated by "C" on the diagram, and the calculation and billing for all the water which enters each separate building to the owner of that building.

DISCUSSION.

THE PRESIDENT. Gentlemen, this paper is now before you for discussion.

PROF. EDWARD W. BEMIS.* Mr. Chairman, we have been experimenting a good deal with meters, as you know, in Cleveland, and we have now perhaps more meters than in any other city in this country. We have about 68 000 meters in use. I should think from our experience that almost all the points which have been made in this paper were sound, with possibly one exception, so far as I noted. That was with regard to the graded system of rates. I think that it is necessary to have your rates so adjusted as to get the revenue necessary for the department, and it may be necessary to have a much higher rate for small consumers than for large ones. It certainly is true that it costs much more for a small consumer, in proportion to the water he uses, than it does for a large consumer; and, so far as the paper suggested a minimum rate, it seems to me that our experience in Cleveland would endorse that thoroughly.

But I was thinking more particularly of the concluding sentences of the paper, in which it was proposed to have a rate which would vary with the amount used. That is practicable, it strikes me, although we do not have it in Cleveland. We have

* Superintendent of Water Works, Cleveland Ohio.

there a uniform rate for all consumers, large and small, although we do have a minimum rate which varies with the size of the meter. It is practical to have two rates, — a rate for the first thousand feet a month perhaps, or the first two thousand feet per month, if you prefer, and a lower rate for all in excess of that. But there is an objection, and a very serious one in my mind, to having several gradations of rates for large consumers. If you simply desire to have a rate for the first one thousand or two thousand feet that shall be much higher than the rate for all in excess of that, you are not doing injustice to anybody, and you are to some extent following out the theory that, since it costs more for the small consumer, he should pay more, for there is a marked difference between the character of the consumers you would hit by your rate for the first one or two thousand feet a month and those who use more. The class that you would hit by your higher rate would be the residences, and such gradation as I speak of would give a lower rate to business properties as contrasted with residences; and, in view of the great difference in the cost of supplying to the two, that does not look to me unreasonable.

The moment you have a series of gradations between business properties, you give the large fish a greater opportunity to swallow the small ones. You then give a wholesale rate to one business man and a retail rate to his small rival in the same line of business.

That is common in private business, and we do not criticise it, — we expect it, — and I do not know, therefore, that I would expect a private water company to do very differently in that respect from a private business in ordinary lines, unless prevented by law. I am speaking more particularly now of a municipally-owned plant, and it seems to me that we more and more expect a city to give the same show to every man. Where there is a difference in cost, as there is between the small and large user, we may admit it, so far as making a higher rate to residences than to large users; but a business man competes with his neighbor; he does not compete with the residents, he does not compete with the householders, but a large hotel is competing with a smaller hotel, a large store is competing with a smaller one, a large factory with the smaller factory, and it violates my theory of the function of government to give a special rate in such case, any more than the

government gives a special rate to those who buy a large amount of stamps, whether it be for postal purposes or for internal revenue purposes. The government does not do that in any country; nor in taxes do we make a special discount to a large taxpayer.

Yet I can see how there may be cases, in a small town, where there is some one consumer, like a railroad, perhaps, that uses a very large quantity of water, with no rival in that line of business in the town at all, and where if it had to pay as high a rate as does the ordinary business it would find it to its profit to pump an inferior grade of water, perhaps, from some nearby stream. And I can conceive the propriety in such a case as that of a reduced rate, if the water works feels that it is still a profitable contract and better than not to have the business at all. I think that is to be avoided if it is possible, and I am only speaking of a possible exception where a town wishes the revenue, and cannot get it at all from such a large consumer unless it makes a further third rate, we will say, or a third step in the gradation for such a class of users. But I wouldn't do it then, I had rather lose the consumer, if it means discriminating against some rival in the same line of business. It strikes me that we cannot do that in a municipal plant, and I do not think we would have to do it. I think we can accomplish what we are after by having a minimum, and then, perhaps, having two gradations in our rates.

Mr. W. C. Hawley.* Mr. President, I do not understand why a municipality should do its business any differently than a private corporation. As I understand the matter, furnishing water is not a municipal or governmental function, such as police protection, fire protection, or building streets. At any rate, in some states it has been decided by the courts that when a municipality enters upon the business of selling water, it does so on exactly the same basis as any private corporation. That being the case, it seems to me that the principle of wholesale and retail ought to enter into its business.

It is a difficult proposition to establish a schedule of rates along the lines which have been pointed out or suggested, and incorporate in it that principle of wholesale and retail business without

* General Superintendent, Pennsylvania Water Company, Wilkinsburg, Penn.

inflicting a hardship upon some portion of the consumers. It seems to me that it could better be done by taking into consideration those costs of furnishing water, such as interest, depreciation, sinking fund, maintenance, — taxes in the case of a private corporation, — and general expenses, such as salaries, office expenses, meter reading, etc., which have nothing to do with the quantity of water furnished, and dividing those costs among the consumers. Probably the best unit in that case would be the unit of family. Of course you have got to include the business houses, etc., and there will be some difficulties in arriving at an exactly equitable division, but some basis can be found by which those costs which bear no relation to the cost of furnishing water, that is, the pumping of so many gallons, can be divided accurately among the consumers, and thus a minimum rate fixed. Then take the cost of furnishing the water, pumping, filtering, etc., and fix that at a reasonable price, and let that water be sold in addition to the minimum rate which has been established by dividing the other costs among the consumers. In that way the benefits of the plant will be conferred upon all at equal rates, and a large user of water will get his supply at a somewhat lower price than the small user. In other words, the principle of wholesale and retail will obtain.

I am glad to see that the writer of the paper speaks of dividing the cost of the plant, and, in arriving at the cost of water furnished, includes only that portion of the plant which is not necessary for fire protection. It seems to me that there is a line which we water-works men must draw and emphasize, until the public at large is educated to the difference between the expense of furnishing water, — so many thousand gallons, — and the expense of furnishing fire protection. A company with which I am connected has recently had a case which has gone through the Supreme Court of Pennsylvania on that very point. The question came up as to what was a reasonable rate for fire protection. We called in experts and we designed a plant covering exactly the same ground as the plant in question, but to supply domestic and manufacturing use only. Fortunately there was very little manufacturing involved in that case. We took the fair value of the plant as it stood, and deducted from it the cost of a plant

for domestic and manufacturing service only, and the difference we maintained was the cost of furnishing fire protection, and that on that cost we were entitled to a reasonable return.

The lower court, after a most ridiculous hearing of the case, apparently decided arbitrarily, without any reasoning whatever, that a certain amount, less than half what we asked for, less than half what we showed we were equitably entitled to, was a reasonable amount. The case went to the Supreme Court of the State of Pennsylvania, which honorable body at the same sitting was able to determine that a two-cent rate per mile for passenger service was not a reasonable return upon the money invested by a railroad for passenger service, but could not see the difference between a 6-inch pipe to furnish fire protection and a 1½-inch pipe, which would be plenty large enough, to supply domestic use. That question will be fought out later. It is a question of vital importance to private water companies, and I think as a matter of good bookkeeping and a just and equitable division of costs, it is a matter of great importance to municipal plants as well, and I am glad that it is emphasized in this paper. I hope that others will have occasion to bring that point to the front, so that the general public will become educated.

MR. ARTHUR A. REIMER.* One point on which the writer of the paper touched introduces a question which has been considered somewhat in our city, and I should like to know what the experience of the members is upon it, and that is the question of making one or several charges against several properties under one management or one ownership. That has become quite a live subject with us within the past few weeks. Our plan up to this time has been to make a separate charge for each separate connection, but one party is belaboring us now pretty strongly because we are doing that, and wants us to make one charge on his various properties. I was wondering if any of you have been confronted with such a proposition, and what your solution of the question has been.

MR. HAWLEY. Put a meter in each property and charge for each property supplied.

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* Superintendent of Water Works, East Orange, N. J.

MR. HUGH MCLEAN.* This meter question I see, gentlemen, is always with us.

About four or five years ago, when the matter was discussed at length in Boston, practically the same questions came up. At that time I represented the city of Holyoke, and described the adoption of a flat meter rate, that is, water to be sold to all consumers at the same price. One of my reasons for it at that time was that the plan then proposed ought to cure the evil that the last speaker has referred to. The tendency of the times then was for consolidation of interests, and the tendency of the times to-day is the same. By a consolidation of interests, using so much more water, these interests got their water cheaper, thereby lessening the revenue of the department. For instance, at that time we sold water per quarter, I think it was at the rate of 15 cents per 1 000 gallons for the first 50 000 gallons; for all over and above 50 000 up to 200 000 gallons the rate was 10 cents a 1 000 gallons, and for all over and above 200 000 gallons the rate was 5 cents per 1 000. So by the consolidating of interests, such as four or five or as many as twenty concerns joining together under one management, the loss to the department of the benefit in revenue of the maximum rates as charged to each individual concern was equivalent to about $3 000 per year.

There was nothing to prevent the consolidation of other interests, which would lose to the department more of its revenue. I cited at that time, I think, the possible consolidation of the large department stores, whereby inside of each store the elevators might be operated by the elevator company. I suggested the possible consolidation of the landlords' association or the saloon-keepers' association, which could be accomplished just as well as in the case of two of the large industries which I cited as having consolidated.

That situation confronting us, it seemed to me that the claims of many of the citizens that they were entitled to the same rate, they being equal shareholders in the water department with the other taxpayers, had a good deal of justice, and we set out to change the rates and make one uniform rate. As I stated to begin with, the rate, I think, was 15 cents, 10 cents, and 5 cents.

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* Water Commissioner, Holyoke, Mass.

We prepared tables showing what the loss of revenue would be under different ratings. With our engineer and our registrar and superintendent, we finally agreed on a flat uniform rate of 5⅔ cents per 1 000 gallons, raising it two thirds of a cent above our lowest rate. That increased the rates, I think, to three or four consumers in the entire city, and reduced them to the balance. Our revenue was decreased, however, but slightly, and the system of having one flat uniform rate, the same to all, is working in a very satisfactory manner.

A further result has been in encouraging the introduction of meters, because those who wish to put in meters can buy all of their water at the flat rate; that is very evident. It is working along the lines of decreasing the per capita consumption, as more meters are being installed, and, as I have reason to know, it is lessening our expense for extensions by decreasing the consumption. It is paving the way for a filtration system, whereby we can lay aside some of our surplus to perfect the quality of the water supplied, instead of using it in extensions.

What was said a few minutes ago by Professor Bemis, that it was an injustice either for a public or private water corporation to have different rates, appealed to me. The United States government, as he cited, and as I cited at one of the meetings in Boston some years ago, sells stamps to Wanamaker the same as it does to me. If Wanamaker buys $10 000 worth of stamps, he pays at the same rate that you and I pay. The United States government's tariff is the same on small and large importations. Why should the small user of water have to pay three or four times as much for water as the larger user? I think it is an injustice, and I think we have solved the problem in Holyoke by making a flat rate and placing a rental on the meter. We put the meter into the applicant's premises free, and we charge him a percentage on it which is about 10 per cent., with a minimum of $2 00 per year, or 50 cents a quarter.

MR. ALLEN HAZEN. Do you charge for the use of the meter in addition to the five cents per 1 000 gallons, or does that cover everything?

MR. MCLEAN. We charge rental on the meter as already explained.

MR. HAZEN. It seems to me that they are on the right track in Holyoke, Mr. President.

THE PRESIDENT. I have thought so for some time, Mr. Hazen.

MR. MCLEAN. The minimum charge is the same to all using the same size of meter. If a mill wants a large meter, which costs a lot of money, we charge them in proportion, — ten per cent. Ten per cent. is our rate for rental, and we keep in repair and renew the meters.

MR. J. H. CHILD. There is one element of service from which, in the way the thing has worked out with us, we are getting no revenue, but from which we should get a revenue, in installing meters. We have a small system and have begun to install meters, first, on the factories and for the large consumers. The practical result of that has been that as soon as we placed the meters, — they had previously paid a flat rate which covered every use of water, the sprinkler heads, and private water hydrants, — the bills went up, in spite of the fact that some time ago we adopted a sliding scale, and some of them got their water for a very low figure. Then they started to drilling wells and eventually cut out almost the entire consumption of water from the water works. They have got an actual money return in their lower insurance rates because of the fact that they have water on their sprinklers at about 140 pounds pressure all the time. Now how to get a proper return for the service is a thing which has been puzzling us. We have in mind a charge of so much per head for the sprinklers, and a lump sum for each hydrant, that charge not to be operative if they use water to an amount that would exceed the minimum charge. I should like to know if that has ever been worked successfully in any other place.

MR. MCLEAN. I will state. Mr, President, what I forgot to say when I was on my feet before, that in our city we have a flat charge of $8 a year for hydrants, which the city pays. We charge that as a rental to the fire department for the use of water. We sell water to all of the public buildings the same as we do to individuals, *and we pay taxes to the city* the same as any private corporation. We paid last year $22 000 of taxes into the treasury of the city of Holyoke, which is the equivalent of the levy at the

regular tax-rate on the valuation of our plant. That in my opinion is the proper application of municipal ownership.

THE PRESIDENT. In answer to Mr. Child I should like to state that this question has been pretty thoroughly gone over in this Association in years gone by, and I do not think that as yet any satisfactory solution has ever been arrived at; I never heard of any. At one time a committee was appointed by our Association, including insurance men in its membership, and the committee presented two reports.

MR. CHILD. One of my commissioners is a manufacturer, connected with one of the large plants, and he has told me how the thing works out. One concern, after sprinklers were installed, got a reduction of its insurance from $850 to about $150 a year, the entire cost of the installation of sprinklers being paid for in two years. They are getting the profit of that, and we are getting almost nothing.

MR. ALBERT BLAUVELT.* Mr. President, the subject of how to regulate charges for private fire services, as you know, has been pretty well threshed over, but it may be profitable to take a moment's time to point out why it is that no rule can be devised except to size up the commercial needs of each individual case. A party installing a sprinkler equipment is under no necessity to use the public water system. It does not make any difference where he is located, whether he is in the middle of a prairie or in a town.

Under the rules of the National Fire Protection Association, — which association includes in its membership all classes of insurance bodies, and I am glad to say now includes a great many organizations which are not insurance organizations, and hopes to include water works associations in due time, — a party installing a sprinkler equipment for his private fire protection has two sources of water supply. You can always find out in an individual case what it will cost the plant to put in its second source of supply. That will depend entirely on the magnitude of the plant and the circumstances in connection with the plant. In some cases, perticularly in the West, a second source of water supply can be installed to entirely dispense with the public water service for com-

* Assistant Manager, Western Factory Association, Chicago, Ill.

paratively little money. In some small plants an air-pressure tank can be used, and the entire installation will not cost more than $800 or $900. In some other cases it would be necessary, perhaps, for the party to put in a large water tower or an elevated tank, or he might have to put in a big cistern or reservoir and an underwriters' pump, so that the expense of replacing the city water might run up to $7 500. In a rough way you can say that to dispense with city water for an ordinary protected plant will cost from $1 500 to $3 000, although it might come to only half of that or might come to several times as much. Now, interest, depreciation, and up-keep of that second source of supply, whatever it may be, will always be somewhere between 15 and 20 per cent. The parties owning the property, perhaps, will not admit it, but you all know very well that interest and depreciation and up-keep of any kind of apparatus will never be less than 15 per cent., and in some cases it will be more than 20. So if your party is up against a problem of spending $2 500 to dispense with city water altogether, you can figure that he can afford to pay you somewhere between 15 and 20 per cent. on that amount rather than to put in his private equipment. You will not find any of these plant owners who will admit that the saving in the cost of insurance has anything to do with the case. It is purely a matter of the investment necessary and the amount of the fixed charges which must be met in order to do without the public water works' service, which again can be done in any and all instances.

THE PRESIDENT. I should like to ask Mr. McLean at what size of meter he draws the line for his minimum charge of $2; that is, what is the smallest.

MR. MCLEAN. Three quarters of an inch.

THE PRESIDENT. From that upward do you charge rental at the rate of 10 per cent.?

MR. MCLEAN. Ten per cent.

MR. LEONARD METCALF.* I have been exceedingly interested in listening to the paper and to the discussion which has followed it, particularly to that suggestion of Mr. Richards that the cost of the fire service should be deducted from the cost of the entire

* Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

service before determining the rates, for it has seemed to me that the tendency to-day in our American cities has been rather in the opposite direction than in the direction of making payment to the water department which should in any way approximate the cost of furnishing hydrant service. I have looked into the question in a few cases, and I never have found a case in which the hydrant rental approached the actual cost of furnishing that service. It seems to me that in the case of Holyoke, for instance, $8 per hydrant cannot cover the cost to the water department for furnishing that service; so I was going to ask the speaker whether the rate of $8 per hydrant was based upon a computation of the cost of furnishing hydrant service; and I would also ask Professor Bemis what their present method of taking care of this matter in Cleveland is.

MR. MCLEAN. The cost of $8 a hydrant was settled upon between the city and the water department when the agreement to pay the tax rate, that I have referred to, was made. That was before I came on the board. Our engineer, who is here, was a party to that agreement. Previous to that conditions were different; we did not pay any taxes, and we charged the departments a certain amount per year and didn't meter the water. The rate of $8 a hydrant I think was based on something near the cost of installing the hydrants. The agreement was entered into between the city and the water department in consideration of the latter paying a tax, and the former paying for all water used, the same as all other corporations, and the city to pay $8 a year for every hydrant as they were added.

MR. METCALF. That is, you are in effect putting upon the water taker the cost of furnishing the hydrant service, that is, the cost in excess of the amount which you are paid?

MR. MCLEAN. I don't know as it is in excess. As I say, Mr. Tighe can answer that question; the matter was agreed to before I was on the board.

MR. JAMES L. TIGHE.* It was estimated to be the interest on the cost of the hydrant and the cost of installing it, and does not include anything for the water service.

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* City Engineer, Holyoke, Mass.

PROFESSOR BEMIS. In answering the question which was asked with regard to Cleveland, I would say that some of our states suffer very much from the failure of home rule; we are not allowed to do as we would like by reason of state legislation, and this is true in regard to this particular point. The state law of Ohio absolutely prohibits any municipal water works from charging a cent for any water used for fire protection, public schools, hospitals, or charities. I do not exactly understand what led to the passage of the law, which is quite old, but it prevents our taking any action. However, we have done one or two things in Cleveland which have helped us some. We have metered the hospitals, and schools, and public buildings, and an agreement has been entered into under which it has been left to a prominent judge to arbitrate the question whether we haven't a right to charge for an excessive use in the schools and hospitals and charitable institutions, — that is, whether the state law contemplated an unreasonable use, or contemplated the use of water as a substitute for coal; for instance, in the running of elevators and fans, and for the manufacture of ice in the hospitals. All those uses of water are being enjoyed by the various institutions. And we are hoping, if we get a favorable ruling as to what is "reasonable use," to make the school department pay for any excess over that reasonable use per capita for every child in daily attendance. At the present time the use of water varies from 3 or 4 gallons per day per child in average attendance during the days the schools are in session to 50 gallons per day per child in average attendance. It is less now than it was before we put on meters.

We meet the question of fire protection by having a rate varying according to the size of the service. Parties are not allowed to use water for fire protection unless it is metered, or unless they pay a charge according to the size of the service. That is working very satisfactorily, and has met the approval of the fire underwriters.

THE PRESIDENT. It may be interesting to the members to know that in the city I represent * we are allowed to charge $25 a year for the rental of hydrants on our books, but they do not

* Springfield, Mass.

pay us any money. We are also allowed to furnish the schools and all public buildings, and water for flushing the sewers and watering the streets free. We have that privilege. We get no money whatever out of the municipality. We hope that sometime all that will be changed.

MR. MCLEAN. Do you pay taxes?

THE PRESIDENT. We do not pay any taxes. I think we would prefer to have the same arrangement that they have in Holyoke.

MR. MCLEAN. I should like to ask Professor Bemis if in his opinion it is not the fairest way to meter all the water for the schools and for the different departments and have them pay, the same as other individuals and large users of water, and then have the water department pay a tax, the same as other corporations?

PROFESSOR BEMIS. I believe in that most thoroughly. It is not simply taking the money out of one pocket and putting it into the other, but it makes each department more careful of its own expenditures and own wastes. For instance, if each department at Washington had to pay the post office department for its use of the mails, it would be far more careful of waste, even though it all comes out of the government treasury in the end. But if you cannot do that, if the law does not permit that, I think every water-works department should establish a system of bookkeeping and publish to the community every year just what each public building and each department costs to the water department. You can often get a very considerable reduction in waste, after you have metered the water, by presenting the matter in a tactful way to those in charge. For example, we have succeeded in having all the public fountains closed at night; before we had meters they were kept running night and day. We found that when there was free use of water in the cemeteries, in our best cemeteries there was more water being used per capita than the same number of people used when living. [Laughter.]

MR. FRANK L. FULLER.* I will say just a word, Mr. President, in regard to the arrangement at Wellesley, Mass. There we consider the meters as a part of the water-works plant, and we have

*Civil Engineer, Boston, Mass., and member of Water Board, Wellesley, Mass.

a minimum rate of $6 which entitles the consumer to 16 000 gallons per year, at the rate of 37½ cents per 1 000 gallons. If they use in excess of that amount the price is $0.25 for the excess. We charge every one the same price, which I think is right. I always have thought that families should not be called upon to pay a higher price for their water, which is an absolute necessity to them, than is paid by those who use water for profit. A good many greenhouse people have thought that they should have water at a less rate, but the rate has always been maintained at the same price for everybody, and I think it gives general satisfaction. The town makes an appropriation for water used in the street sprinkling and for that used in fountains and for the hydrants. The water used in the public buildings is also metered. We do not meter the water used in street sprinkling, but there is an account kept with that by the number of loads of water put upon the streets.

I should like to say just a word in regard to the question which has been raised about the payment of water rates by the landlord. Of course our town is different, I suppose, from the case Mr. Richards spoke about in his paper. We always send the bill to the tenant, and the tenant pays the water rates, the same as he pays his other bills. The landlord has nothing to do with it. I suppose, perhaps, the landlord might be responsible for the water rates, but we have never had a case where the tenant didn't pay. As I remember it, we have only a few cases where one meter would cover several families, and we have endeavored to arrange it so that each tenant has his own meter and is charged for the water he uses the same as any one else.

MR. H. N. PARKER.* I have recently had the pleasure of visiting most of the public water works systems in the state of Kansas, and I was very much surprised to find how generally meters are used throughout the state. As we all know, here in the East the introduction of meters has met with a good deal of opposition, but there it seems to be taken for granted that it is a just and equitable way to sell water, and the town is the exception, I think, which sells water in any other way than by meter. They

*Assistant Hydrographer, United States Geological Survey, Washington, D. C.

have different ways of selling it, but the use of meters is practically universal, and it is only a question of time before all the towns in Kansas will be completely metered.

Mr. W. H. Richards (*by letter*). It is a matter of satisfaction to know that there was no endeavor to controvert the logic of my statements that the only equitable way to sell water is by measure; that the reason for the introduction of meters is equity between customers, and that the charge for water should be based on the cost of supplying the same to the particular party under consideration.

If it costs less to supply a large quantity than a small quantity, then the rate should be less for a large quantity. If a large quantity is drawn through one service pipe, then it costs less. In the case of fire hydrants the quantity of water is comparatively so small as to be negligible, and the cost is in the hydrants and the extra large pipes through which the water is drawn, and they should be so charged for. The same holds good for private fire service.

I agree with Mr. Hawley that a municipal water works stands on the same footing as a private corporation, and further, that the taxpayer has no interest in the water department except in so far as the municipality uses water; and every public use should be paid for on the same terms as a private use.

If, as I understand was the case at Holyoke, all the water used through many different service pipes was grouped together and charged on one bill, then the cost of the service pipes and mains to furnish the supply was neglected, and the reason for a graduated rate was circumvented. If the rules had required the charge to be based on the quantity drawn through *each* service pipe, then the laws of logic and equity would have been satisfied. If the Holyoke water department can supply water at 5¾ cents per thousand gallons it has built its system at a very low cost. If it is supplying water in very large quantities to manufactories at the same cost as to residences, it is charging a larger proportion of the cost to one than to the other.

The illustration of the charge for postage is an argument in favor of graduated rates, since the charge for other than first-class matter is less because the service is less valuable, just as water is

less valuable to the manufacturer than to the party using it for domestic purposes.

In reply to Mr. Fuller, it goes without saying that to prevent loss, the water rent should be a lien on the property, and hence the owner is liable; otherwise there is no way of collecting the water rates except by a suit at law for debt, and if two tenants are supplied through one service pipe, to shut off the one who will not pay, necessitates shutting off the one who has paid.

RUBBER PIPE JOINTS.

BY ROBERT SPURR WESTON, SANITARY EXPERT, BOSTON, MASS..

[*Read September 24, 1908.*]

During the past winter in Europe the writer noticed that much water pipe was being jointed with pure rubber rings in place of the customary lead and yard. It is thought that this simple process might be of interest and use to the members of this Association. The process was very simple. The rubber ring was slipped over the spigot end of the pipe, the spigot of this pipe was then forced into the bell of the next pipe by means of a long lever, compressing the rubber between the iron surfaces and making a very tight joint. Clay was then forced into the remaining space and the job was done.

The following information was obtained regarding this method of jointing. To begin with, the "Normal" pipe of the *Verein deutscher Ingenieure* has the form shown in the following sketch (Fig. 1).

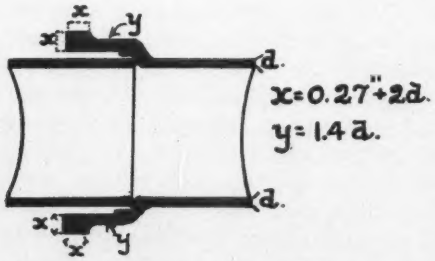

FIG. 1. "NORMAL" CAST-IRON PIPE OF THE VEREIN DEUTSCHER INGENIEURE.

The thickness of the shell of this normal pipe is determined by the formula

$$d = 6.0 + 0.001 \times D \times A = \text{thickness in millimeters.}$$

where

D = inside diameter in millimeters.
A = testing pressure of 20 atmospheres.

The German pipe is made in more sizes than is customary in this country. A few of the dimensions of the "Normal" pipe corresponding to the standard New England Water Works Association pipe diameters, and expressed in equivalent United States units of measure, are given in the following table:

SIZES OF GERMAN "NORMAL" PIPE.

Inside Diameter. Inches.	Millimeters.	Outside Diameter, Inches.	Laid Length, Feet.	Diameter of Sockets, Inches.	Depth of Sockets, Inches.	Width of Joint Space, Inches.
4	100	4.65	9.9	5.24	3.46	0.30
6	150	6.69	9.9	7.28	3.70	0.30
8	200	8.75	9.9	9.37	3.94	0.32
10	250	10.78	11.1	11.44	4.05	0.33
12	300	12.82	13.1	13.10	4.13	0.33
14	350	14.88	13.1	15.53	4.21	0.33
16	400	16.89	13.1	17.64	4.33	0.37
18	450	18.90	13.1	19.63	4.41	0.37
20	500	20.93	13.1	21.73	4.53	0.39
24	600	24.97	13.1	25.78	4.72	0.41
30	750	31.10	13.1	31.98	5.00	0.43
36	900	37.20	13.1	38.18	5.31	0.49
48	1,200	49.40	13.1	50.52	5.90	0.51

It will be noted that the "Normal" pipe differs in many particulars from the New England Water Works Association "Standard" pipe, e.g.:

First, there is neither bead on the end of the spigot nor retention spaces for the lead in the bell.

Second, the socket is deeper and there is a shoulder in the bell which serves the purpose of the bead on the New England Water Works Association standard pipe.

Third, the increases in dimensions of socket vary more uniformly with the increase in diameter of the pipe.

Fourth, should the shell of the pipe be thickened, the outside diameter remains constant.

In thickness of shell, the German pipe lies between classes A and B of the New England Water Works Association standards, as the following table will show:

THICKNESS OF PIPES.

"NORMAL" PIPE OF THE VEREIN DEUTSCHER INGENIEURE COMPARED WITH STANDARD PIPE OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

DIAMETER.		THICKNESS OF SHELL. INCHES.			
Inches.	Millimeters.	Ver. d. Ing.	N. E. W. W. Assn. Class A.	Class B.	Class C.
4	100	0.35	0.34	....	0.36
6	150	0.39	0.38	....	0.42
8	200	0.43	0.42	....	0.48
10	250	0.47	0.47	0.50	....
12	300	0.51	0.49	0.53	....
14	350	0.55	0.53	0.57	....
16	400	0.57	0.55	0.60	....
18	450	0.59	0.57	0.63	....
20	500	0.63	0.60	0.66	....
24	600	0.67	0.64	0.72	....
30	750	0.79	0.71	0.81	....
36	900	0.89	....	0.90	....

The German pipe is recommended for general use with pressures varying from 60 to 105 pounds per square inch.

Pipe for use with rubber rings should not have the retention space cast in the bell, and the spigot may have a groove 0.2 inch deep to prevent the ring slipping during process of jointing. This groove is sometimes omitted. The pressure which the joint will withstand depends upon the degree of compression, and consequently the holding friction of the rubber ring. The groove permits a thicker ring to be used than is possible without it.

The following sketch (Fig. 2) shows how "Standard" pipe may be adapted for use with rubber rings, and the degree of compression

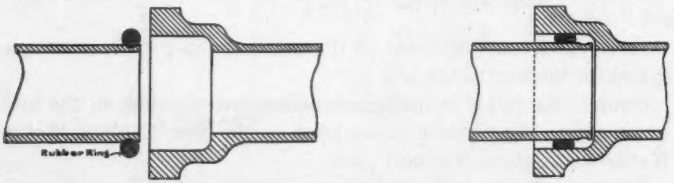

FIG. 2. METHOD OF JOINTING PIPES.

to which the ring would be subjected in practice. The thickness of the ring before compression should be twice the width of the joint. The inside diameter of the rings should be somewhat less than the outside diameter of the pipe, that they may be held in place by their own elasticity during the processes of jointing.

The sizes of the rings for pipes of classes A, B, and C would be as follows:

Diameter of Pipe, Inches	Inside Diameter of Ring, Inches.	Thickness of Ring, Inches.	Weight of Ring, Lbs.
4	4.50	0.80	0.136
6	6.50	0.80	0.195
8	8.50	0.80	0.247
10	10.25	0.80	0.294
12	12.25	0.80	0.348
14	14.25	0.80	0.401
16	16.25	1.00	1.437
18	18.00	1.00	1.582
20	20.00	1.00	1.747
24	24.00	1.00	2.081
30	30.00	1.00	2.45
36	36.00	1.00	3.08

The rubber rings used should be of the best pure gum, preferably the variety known as Para gum. They cost from $2.50 to $3 a pound at present prices, and are usually made of pure gum rods, butt-jointed and vulcanized. Their cross section is circular. Rings of hemp coated with rubber have been tried but are not to be recommended because of their low elasticity, upon which the tightness of the joint depends.

The comparative costs per joint of lead and rubber joints may be estimated as follows, assuming lead to cost 5 cents and rubber $3 a pound, and using New England Water Works Association Standard pipe without the retention space:

COMPARATIVE COSTS OF LEAD AND RUBBER PIPE JOINTS.

Diameter of Pipe, In.	Thickness of Joint, In.	Estimated Cost of Lead, Yarn, and Calking.	Cost of Rubber Ring.	Cost of Laying.	TOTAL COST PER JOINT. Lead.	Rubber.
4	0.40	$0.54	$0.48	$0.09	$0.63	$0.57
6	0.40	0.86	0.58	0.12	0.98	0.70
8	0.40	0.97	0.74	0.15	1.12	0.89
10	0.40	1.21	0.88	0.20	1.41	1.08
12	0.40	1.48	1.05	0.24	1.72	1.29
14	0.40	1.78	1.20	0.30	2.08	1.50
16	0.50	2.08	4.31	0.36	2.44	4.67
18	0.50	2.39	4.75	0.42	2.81	5.17
20	0.50	2.68	5.24	0.48	3.16	5.72
24	0.50	3.60	6.25	0.60	4.20	6.85
30	0.50	5.30	7.34	0.90	6.20	8.24
36	0.50	6.51	9.24	1.17	7.68	10.41

It will be noted that up to and including 14-inch pipe the rubber joint is a little cheaper, even without allowing for the cost of bell-holes not needed for jointing with rubber rings. There is no reason why the width of joint for pipe 16 inches in diameter and above could not be reduced to 0.45 inch, or even 0.40 inch, when the cost of rubber joints would be less than that of lead joints, as shown in the following table:

COMPARATIVE COSTS OF LEAD AND RUBBER PIPE JOINTS FOR PIPE 16 INCHES AND OVER IN DIAMETER, HAVING A JOINT SPACE 0.40 INCHES WIDE.

Diameter of Pipe, Inches.	Cost of Joint.	
	Lead.	Rubber.
16	$2.44	$1.89
18	2.81	2.11
20	3.16	2.31
24	4.20	2.82
30	6.20	3.56
36	7.68	4.13

The advantages and disadvantages of the rubber joint may be stated as follows:

One of its chief advantages is that it is extremely flexible. The rubber ring is midway in the bell and therefore at the axis of movement. Therefore no serious unequal compression of the ring can result if the pipe be thrown out of line. The joint is almost perfectly tight and needs no calking; it may, therefore, take the place of flanged pipe for suction mains connecting tube wells. In such cases the position of the branches may be adapted to suit the wells. This is often a great convenience because it is impracticable in all cases to sink wells in exact predetermined positions. Pipe with rubber joints is easier to lay on account of the absence of bell-holes and the simplicity of the jointing tools. There is less breakage of pipe due to settlement of earth. It resists electrolysis most efficiently. The rubber joint, on the other hand, has not been used for high pressures. How much pressure it will withstand could not be ascertained. It is in use in systems which carry 50 pounds pressure, and probably could be used for pressures considerably higher. The joints appear to be durable. If exposed to air, rubber absorbs oxygen, loses its elasticity, and becomes hard and useless. Compressed in a pipe joint, however, it

is preserved. A ring removed after eighteen years of service was apparently as good as new. It would be more durable in contact with ground water than with surface water.

Many German and European supplies are from wells driven in gathering grounds located above the level of the city. In several instances the water is siphoned from the wells to the distributing reservoir by means of rubber-jointed pipe. The proposed new water supply of Prague contemplates such a line from the mountains several miles distant from the city.

This paper is written with the hope that some members of this Association may try these joints and determine their worth under the conditions of American water-works practice. While not at all new, they have not been tried in this country to any great extent. The writer wishes to thank Dr. A. Thiem, C. E., and Mr. A. Lang, C. E., of Leipsic, for information regarding the use of this joint.

DISCUSSION.

THE PRESIDENT. Gentlemen, the paper is now open for discussion.

MR. ALLEN HAZEN.* Mr. President, I had the good fortune to see these joints in use in Germany about fifteen years ago. I think the joints were comparatively novel at the time, and if I remember, in speaking to this Association after my return, I mentioned them. They were used at that time in suction mains. They were used because by their use it was possible to get a line which was perfectly air-tight, and a lead joint, as you know, cannot be maintained air-tight. I gather from what Mr. Weston says that their use has been extended, and the extension certainly is a very interesting fact.

I wonder if Mr. Weston knows if in France and Belgium joints have been made partly of rubber and partly of lead, with the idea of combining some of the advantages of both materials.

MR. WESTON. I haven't heard of joints being made of rubber and lead, but I have heard of joints being made of hemp rings coated with rubber, with lead poured on top. A rubber compound ring, which is very similar to our pipe joint packing, is more water-tight than yarn, of course.

* Consulting Engineer, New York City.

MR. MURRAY FORBES.* In case one of those joints should give out, how are the repairs made? Do they have to pull the pipe apart again?

MR. WESTON. Yes. It is doubtful if rubber joints are practicable where frequent repairs or changes are to be made.

PROF. E. W. BEMIS.† Isn't the Standard Oil Company using the Dresser coupling for high pressures of natural gas?

MR. WESTON. I cannot say.

PROFESSOR BEMIS. They are using it for their distributing system entirely in many cities of the West where the pressures are not as large as 60, — and are down to 40 pounds in some cases, — but I think they are using them in their mains running up from West Virginia where they have 300 to 400 pounds pressure. It is not exactly the same thing, but it is a rubber coupling called the Dresser coupling. I haven't examined it very carefully, but it is on the same principle.

MR. W. C. HAWLEY.‡ I might answer the question by saying that there are a great many Dresser couplings used in western Pennsylvania under pressures up to 400 or 500 pounds per square inch for natural gas.

In connection with the matter of pipe joints it may be of interest to members of the Association if I call their attention to a new material, which has come on to the market within two or three years, known as "Leadite," manufactured in Philadelphia. My attention was called to it by a salesman of water-works supplies some two or three years ago, and on his advice I got some of the material and tried it, and I have been using it exclusively now for over two years. It is a mixture of iron filings, sulphur, and silica. It melts at a temperaure considerably lower than lead,— at something like 250° F., I think,—and is poured into the joint in the same way as you pour lead, but it requires no calking. It weighs about one sixth as much as lead and costs about twice as much per pound; therefore per unit of volume it costs one third. The cost of a large bell hole is saved, and the cost of calking, and I believe my joints are costing me from a third to perhaps a half of what lead joints

* General Manager, Westmoreland Water Co., Greensburg, Penn.
† Superintendent of Water Works, Cleveland, Ohio.
‡ General Manager, Pennsylvania Water Co., Wilkinsburg, Penn.

would cost. The material cools quickly with little shrinkage. I have had no trouble with the shrinkage except in some large 30-inch sleeve joints. Repairs are easily made. The material is rather brittle when it is hard, and with a chisel is easily cut out, and you can run the new part of the joint and it takes a firm hold on the old part; the material seems to take hold of the iron when it is clean. I am using it under pressures up to 200 pounds per square inch, and have had no trouble with any of the joints except where we had a slip on the hillside the other day which took pipe and all, and there a little of the leadite crushed out, where I suppose the whole joint would have gone if it had been lead.

It requires rather careful manipulation, and yet our men have had no difficulty with it. Our man who melts it is an eighteen-year-old Italian, and he thinks there is nothing like leadite now. I understand it is in use in Atlantic City, and I presume Mr. Van Gilder can tell us something about it. A contractor recently told me that he had been laying some 12- and 16-inch pipe through a swamp near Reading, Penn., I believe, and he had found leadite very much better for use in wet ditches than lead; he simply left a hole at the bottom of the joint with the water running out of it and poured the hot stuff in and it closed up the joint, making it tight with very little difficulty. The worst trouble we have had is on account of its catching fire if it gets a little too hot, but it is very easy to put the fire out by throwing a few handfuls of the fresh material on, — it comes in the form of a fine black powder, — and my foreman recently told me he found that a bucket of water would put it out quickly without any serious consequences.

THE PRESIDENT. Is Mr Van Gilder in the room?

MR. VAN GILDER.* I do not think I can say anything further as to the use of leadite, except to indorse most heartily what Mr. Hawley has said. We have had no difficulty with it except with one joint, during the two years and a half I have been in this department, and that was in a soft bed under the railroad with very heavy traffic. That is a case where it was impossible to hold a lead joint, and it was impossible to hold a leadite joint because in time it would crumble. We have overcome that since by putting a sleeve over the pipe. We find it to be very superior to lead

*Superintendent of Water Works, Atlantic City, N. J.

in very wet places, for the reason you can pour it in the joint with perfect safety to your men, which would be utterly impossible with lead. We can fill up the joints by pouring in the material quickly, and then we let it chill and it is all done.

MR. HAWLEY. Of course one has to use a much higher "gate" with leadite than with lead, on account of the difference in weight. We make a hollow cylinder of clay, perhaps 6 or 8 inches high, put that over the bell, and pour through that, filling it, and leave it long enough to chill. I think a large joint should be run slowly because there is some shrinkage, just as there is with sulphur.

MR. CHARLES E. CHANDLER.* In connection with rubber joints and air-tight joints for pumping, I will say that there are several miles of cast-iron pipe laid in the city of Norwich, with rubber joints, for transmitting compressed air, which may be of some interest. All of the joints are rubber joints, formed by putting a sleeve over the joint, the pipes not having any bells. A rubber ring goes on each end of the sleeve, and outside of that a double clamp which bolts and squeezes the rubber and makes the joint. The rubber rings are square in section and the clamps are not quite square, so they hug the rubber bands down to the pipe. Those rubber joints can be made just as tight as screwing up the bolts will make them.

The experience there was that after about a year practically all the joints had to be dug up and the bolts tightened. After being in five years, under 90 pounds air pressure, there are a great many leaks. In the center of the city, where brick paving was laid last year, the circumstances are such as to show up the leaks more than ever before, and it is quite interesting to people who go by on the trolley cars. For instance, a leak in the compressed air main in an ordinary street, where there was no paving, unless it was raining, would not show up at all, but when the street was paved with brick the only escape for the air was near the trolley tracks, and when the trolley sprinkler goes along, and there is plenty of water, the pot boils very nicely, and it attracts a great deal of attention.

MR. FRANK L. FULLER. Was that wrought-iron pipe?

* Civil Engineer, Norwich, Conn.

MR. CHANDLER. No, sir; it was plain, straight cast-iron pipe without any bells.

MR. WESTON. I might say in connection with the experience that Mr. Chandler has had in Norwich that I think one would expect that any rubber joints in contact with air would become hard in about two years, or less. Rubber, even the best of rubber, will absorb about 25 per cent. of its weight of oxygen in a very short time when exposed to air, and when it does so it changes from what might be called a gum to a gum resin, just as linseed oil changes from an oil to resin, and in doing so becomes brittle and useless for all purposes where elasticity is of value. I think the cases in which we would think of using rubber joints, or the cases where they are particularly applicable, are those in which the rubber can be protected against the action of oxygen, as it can be in a water pipe, where the space on one side, the outside, would be filled with clay, and on the other by the silt which would come from a surface water and protect the joint, and also on the inside by the carbonic acid gas which is always present in a ground water. I would not think that the rubber joints I have described would be applicable for use with air pipes, but I do think it can be used especially for suction pipes in connection with driven-well systems.

MR. E. S. SAUNDERS. Suppose you had a cracked end and had to cut off the end of a bead end, how would you hold the pipe?

MR. WESTON. I think it would be safer in that case to make a lead joint, or put the lead over the rubber, but in a long line of pipe I think it is perfectly safe to use rubber.

MR. CHANDLER. I suppose it might be proper to say that in France, where they use a great deal of compressed air, they use the rubber joints. Perhaps some one here can tell us whether those air pipes are laid in subways, where they are accessible for repairing the joints. I do not know whether that is the case, but the idea of using rubber joints for compressed air came from the fact that they are used in France. These joints I speak of, of course, have very slight contact with the air. We have the sleeve over the joint and the rubber on the outer end of the sleeve, and the opportunity for air to get to the joint is very slight, but of course it can get there.

MR. WESTON. As I remember, some European rubber joints are made with ordinary flanges and they require packing. I have seen very few cases however.

MR. CHANDLER. Flanged pipes?

MR. WESTON. Regular flanged pipes.

MR. CHANDLER. I didn't think so, but it may be so. The joint I speak of gives flexibility, which of course a flanged joint would not have.

MR. M. N. BAKER. Those interested in the use of leadite for pipe joints can find a considerable amount of further information on the subject in the proceedings of the American Water Works Association for the present year. The consensus of opinion on the part of those who spoke on this material, so far as I remember, was very favorable to it.

MR. WESTON. A recent letter from a German friend states that rubber rings are not being used in general practice for jointing pipes beneath paved streets or where pressures are very high. In such cases, lead and yarn joints are more economical. For work inside of buildings where pressures are high, rubber joints with the rings secured in place by means of an iron ring clamped to the pipe described by Mr. Chandler have been used in place of flanged joints, thereby gaining much flexibility. The new use which is being made of rubber joints is for long mains leading from wells or other gathering grounds across hills and valleys, under vacuum and pressure, to pumping stations or cities. In these cases the superior tightness of a rubber joint outweighs most disadvantages.

MR. WILL J. SANDO. (By letter.) The rubber ring joint has been used between faced flanges inserted in a wedge-shaped groove a great many years with good success.

The sketch by Mr. Weston shows that the rubber makes a parallel joint between the inside of the bell and the outside of the spigot, and the tightness is dependent on the friction of the rubber and metal. In this form it might be blown out by the pressure of the water inside of the pipe. This might easily cause trouble and be very expensive in repairs.

The accompanying sketch (Fig. 3) shows, I believe, a more reliable form of this same joint. It is made by tapering the outside of the spigot end so that the rubber ring will tighten more as it is

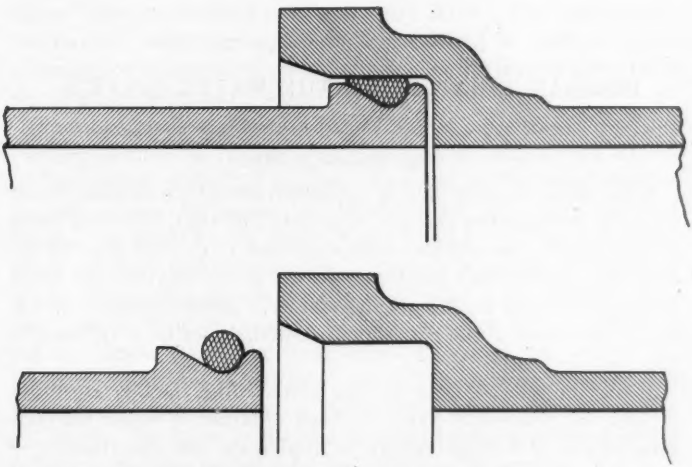

FIG. 3. RUBBER PIPE JOINT AS SUGGESTED BY WILL J. SANDO.

inserted into the bell end and then any additional pressure from the water inside will also tend to make the joint tighter. It seems to me there are places where a joint made in this manner could be used to good advantage.

INSURANCE RATES AND THE WATER SERVICE.

BY FRANK A. BARBOUR, CIVIL ENGINEER, BOSTON, MASS.

[*Read September 24, 1908.*]

Some recent work involving the betterment of the existing water works in several cities and towns, and the fact that, following these improvements, reductions in the insurance rates were granted by the underwriters, has suggested to the writer that a very brief description of the work done, in so far as it affected the fire service and a statement of the reductions allowed, might be of interest to this Association.

It may be possible that in some communities the logical results of such improvements have not been obtained — either through civic inertia or through failure to appreciate the opportunity, — and that the experiences herein described may prove profitably suggestive.

IMPROVEMENT OF ST. JOHN WATER SUPPLY.

In 1905, the development of a new water supply for the city of St. John, N. B., was undertaken, the work involving the extension of the then existing pipe lines from a point about 5 miles distant from the city to a more distant source, at an elevation 138 feet higher than the old supply. The pipe lines to the city included two 24-inch cast-iron pipes, one laid in 1857, the other in 1873, and a 12-inch cast-iron pipe laid in 1851. The distribution system, which was generally of equal or greater age (some of the pipes having been laid as early as 1837), was fairly adequate in size, requiring for efficient fire service additional pressure rather than enlargement of pipe diameters.

The extension of the works to the new supply included 10 000 feet of 33-inch wood stave pipe, 7 500 feet of 39-inch reinforced concrete conduit, laid about 20 feet below the hydraulic grade line and ending in a lake of 600 000 gallons capacity, but with small watershed, from which lake a 48-inch reinforced concrete conduit, 6 200 feet in length, laid partly in tunnel and partly in open cut, connected with the main source of supply, the Mispec

River where a concrete dam was constructed. The total expenditure (not including a pulp mill, purchased in order to avoid damages for diversion of water, which should yield an amount in rental equal to its cost), was about $300 000.

The topography of the city is most irregular, surface elevations varying as much as 125 feet, the higher areas being within 40 feet of the surface of the old supply. Previous to the installation of the new works the system had been divided into a high and low service, the water for the former being lifted by turbine and power pump 35 feet higher than the elevation possible by gravity. Under the present system the city is supplied in a single service, the pipes working in common with full pressure on the mains to the city limits, where two Ross regulating valves are installed by which the pressure is reduced some 15 pounds or to the point where it will drop by friction loss in the mains under an extreme fire draft. In this way the distribution system is relieved of the full static pressure without detriment to the fire service.

The application of the higher pressure to a system of such age was a matter of considerable responsibility and one demanding great care and patience. It was out of the question to undertake a general replacement of the system, as this was beyond the financial capacity of the city. The proof of the ability of the 24-inch mains to meet the new conditions could only be made by actual hydraulic tests in the ground. Examination of individual pipes, while indicating the iron to be of good quality and of the necessary thickness, was of relatively small value, as the breaks would occur in pipes weaker than the average. It was, therefore, decided, to supply the city through one of the 24-inch lines and to test the other main by gradually stepping up the pressure, repairing such breaks as occurred with each increment, and finally applying 20 pounds in excess of the full static pressure of the new supply by developing water-hammer through the operation of blow-off valves. After the weak pipes in the first main were eliminated in this way, this conduit was thrown into service and similar work done with the other main. The 12-inch pipe laid in 1851 was abandoned as of little or no value. When the full pressure of 110 pounds had been applied to both mains, the pressure in the distribution system was gradually increased by manipulating the regulating valves.

By the installation of these new works the pressure throughout the city was increased about 40 pounds, and from four to ten good direct fire streams, the number depending on the variation in surface levels, were made possible, while with engines from ten to twenty streams were obtained. As the commercial center is generally in the lower areas, the possibility of direct service is of great value, especially in a city where the efficiency of the fire department is not up to the metropolitan standard. With the old pipe lines, not more than two direct streams were possible and the maximum draft with engines was probably not more than 2 000 gallons per minute.

RESULTING SAVING IN INSURANCE.

As a result of these improvements a reduction in the insurance rate of 25 cents has been granted on mercantile property, the total yearly amount somewhat exceeding $30 000, which is more than double the interest cost of the entire improvements.

NOTES ON OLD PIPES AT ST. JOHN.

A few notes on the work in St. John in connection with the old pipe lines may be of interest. The pipes in the first 24-inch line, laid in 1857, have a thickness of about three quarters of an inch. The exterior surface shows no signs of having been coated; neither does it show any serious corrosion, the iron when broken being good to the extreme outer edge. About one sixteenth of an inch of the interior surface is black and easily abraded. The pipe is badly incrusted, although it has been cleaned several times in past years by the method used in St. John and Halifax, and already described in a paper read before this Association by the superintendent of the St. John system.* The joints were made of white pine and are in good condition, without leakage under the heavier pressure, except in some places where the key-wedges were badly fitted. A section of this pipe, 3 600 feet long, laid through marsh mud at tide level, was found to be badly disintegrated and was replaced. In many instances it was possible to cut the pipe with a knife through a considerable portion of its thickness. The new

* JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, Vol. XIII, p. 147 (December, 1898).

cast-iron pipe was embedded and wrapped with a layer of clay, since such sections of the old pipe as had been laid in this material have apparently escaped any disintegrating effect of the tidal mud. Pipe laid in sand at about the same level was not affected, and of twenty-one lengths, each 9 feet long and weighing 2 300 pounds per length, only one broke.

The pipe laid in 1873 was of two classes: one, seven eights of an inch thick, and the other one inch thick. The pipe was coated and is in better condition than the pipe laid at the earlier dates. In this line four types of joints were employed: first, a turned and bored joint; second, a turned and bored joint made up with lead and a strap to hold the lead in place; third, a wood-stave joint, and fourth the ordinary lead joint.

In the distribution system relatively few breaks have occurred, although in some cases the pressure is 95 pounds per square inch. The pipes which have been broken have usually been thin on one side, presumably the result of having been cast horizontally. The service pipe was not tapped but driven into the main, with a keeper which extends around the pipe. Local plumbers predicted that these connections would be blown out by the heavier pressure, but only one such case has occurred.

Precise instruments have not been available for the determination of the friction loss in those old mains, but from gage readings and measurements of the discharge by Venturi meters, it appears that the coefficient C in the Chezy formula, practically applicable to these mains, is between 65 and 70, the factor of leakage from the pipes between points of gaging discounting any attempt at greater accuracy.

The gradual stepping up of the pressure on the distribution system by the use of the regulating valves and measurements of the flow by Venturi meters indicated an increase in leakage from the distribution system about 5 per cent. greater than in direct ratio to the square root of the pressure. This leakage, while not of serious moment in the present instance where the supply is ample and obtained by gravity, would, in the case of a pumping system, be as great a factor in the depreciation of the old mains as the actual strength of the pipe. In an endeavor to determine the ocation of abnormal leakage the pipe system is being tested in small

districts between the hours of 12 midnight and 4 A.M. by shutting connections to the section under examination and supplying it with water through a meter set in a hose line stretched from a hydrant outside to a hydrant inside the district. Street after street is then shut off and the effect on the meter noted. Gates are sounded for leakage by the aquaphone, and as an additional check a small meter is placed on some sill-cock and water run through it for a certain length of time. If the water in hose line indicates an equal discharge it is concluded that all water entering the district is being measured. Leakage is an element of interest in insurance rating because of its effect in reducing pressures in the distribution system and may become of serious moment when large in proportion to the legitimate consumption.

IMPROVEMENT OF THE FREDERICTON WATER SUPPLY.

The city of Fredericton, N. B., was supplied by pumping direct into the mains without elevated storage, the pumps necessarily running twenty-four hours. In connection with the installation of a mechanical filtration plant recently constructed, a clear water well of 400 000 gallons capacity was provided, largely as a fire reserve, and the old pump of 1 500 gallons per minute capacity was reinforced by new apparatus of double this discharge. In time of fire a pressure of 80 pounds is maintained at the station, but the effective pressure at the hydrant is considerably less owing to an inadequate distribution system, twenty-four years old, and much incrusted by the action of the river water on the pipes.

RESULTING SAVING IN INSURANCE.

As a result of the installation of the larger pump a reduction in the insurance rate has been made equal in yearly total to about $6 000, or practically three times the interest on cost of the improvements chargeable to fire protection.

IMPROVEMENT OF THE ATTLEBORO WATER SUPPLY.

In Attleboro, Mass., previous to 1904, the principal elements of the distribution system were a single main between the pumping station and the town, and a steel standpipe of 660 000 gallons capacity, with its water surface, when full, 140 feet above the level

of the business center. This standpipe held the night's supply, but in case of fire, owing to inadequate elevation, it was shut off from the system by the closing of a gate and the pressure then obtained direct by starting up the pumps. Improvements carried out between 1904 and 1906 included the construction of a reinforced concrete standpipe of 1 500 000 gallons capacity, with its top 100 feet higher than that of the old standpipe; the laying of a second main between the pumping station and the point of storage, and of a larger main from this latter point to the center of consumption. Under the old system of direct pressure in time of fire the maximum service was six streams with 65 pounds at the hydrant. The new standpipe is of such capacity and height that assuming a sixteen-hour shut-down of the pumps, the storage reduced during this period by the estimated consumption twenty years hence and a fire occurring at the end of the sixteen hours, fifteen streams with 65 pounds at the hydrant can be maintained for one hour without starting up the pumps. In a test made in 1906, sixteen streams discharging 3 800 gallons per minute were shown with a pressure at the hydrant of 75 pounds. *As a result of these improvements a 10 per cent. reduction of the mercantile rate of insurance was allowed by the underwriters.*

GENERAL CONSIDERATIONS.

The three preceding instances of reduction in the insurance rates as a result of improvements of the water service illustrate the value accorded by the underwriters to increased pressure in a gravity system, greater pumping capacity in a direct pressure system, and larger storage and the duplication of mains in a pumping system with standpipe. The amounts of the reductions were determined by committees representing underwriting associations — in two cases as a result of applications made by the municipal authorities after the work was completed, and in this third case, that of St. John, N. B., as a reward promised before the improvements were undertaken. It is safe to say that in none of these cases was there any attempt to estimate the value of the improvements in reducing the fire hazard on any definite basis derived by experiences and made applicable by records of fire losses relative to the character of the water service. It would seem, however, that the

time must soon arrive when such logical proportioning of rates to the factors controlling fire hazards will be possible.

It is true that the water service is only one element in a very complex problem; that the character of building construction and the efficiency of the fire department are of almost or quite equal importance, and that the basic rate applicable to any city must be a product of several factors, each subject to modification as made necessary by the local conditions. With due appreciation, however, of the complexity of the problem, it is believed that a more logical co-relation of the character of the water service and the fire hazard can be developed. The possibility lies in the extension of schedule rating by which rates will be scientifically developed from the accumulated experience of underwriting associations in such a way as to gradually eliminate the personal equation and the discrepancy now existing in the assessment of individual risks. In such rating the proportionate effect of the water service would be determined and the relative value of works of different character made known to municipal authorities.

The ultimate end of insurance associations is not merely the payment of losses; another and most important factor is the work which has been done toward the reduction of the fire hazard by investigations, inspections, and insistence on certain standards of construction and fire fighting facilities. From the standpoint of the insurance company, prevention of conflagrations is a better means of profit than high rates, a result proved by the success of the factory mutuals in which the primary motive is the prevention of fires by the provision of specified standards of construction and facilities for preventing conflagrations. In these companies, rates are scheduled, disabilities penalized, and improvements rewarded with definite financial returns. And it is probable that, as schedule rating, scientifically deduced from the accumulated experiences of many companies and developed by some central controlling board of underwriters, becomes the rule, methods approximating those of the above-mentioned companies will be made applicable to general insurance, in which case deficiencies existing in the different municipal departments which have a controlling influence on the conflagration hazards will be definitely expressed as penalties in increased rates which, by certain improvements, can be removed.

As an illustration of schedule rating brief reference may be made to the Universal Mercantile Schedule developed in 1893 which, in some parts of the country, constitutes the principal basis of rating at the present time. By this schedule a key-rate was to be given each city and town, differing in each as was made necessary by local conditions. These key-rates were to be modified for individual risks in accordance with the variations in construction, occupancy, and other particular hazards; and as a basis for the establishment of the key-rates a standard building in a standard city, with gravity water works, adequate distribution system, efficient fire department, and other attributes, was conceived, and for such a building in such an environment a basic rate was adopted from which the key-rates of other cities might be obtained by additions made for certain deficiencies. This schedule was by no means perfect, and has been criticised in several particulars, but for the present purpose it serves to indicate the possibility of schedule rating and the advantage of definitely making known to each community its standing in the rating problem, its deficiencies and the penalties exacted, and finally the improvements necessary to obtain the basic rate of the ideal city. Under such a method, definite incentives to improved standards in the water service, fire department and building construction are presented by the resulting reduction in rates often made possible of attainment without increased cost to the community. And beyond all this, in broader outlook, there is the possibility that by such cooperation of municipal authorities and underwriting associations a long step would be taken toward the actual conservation of property values by lessening the fire losses, which the payments of insurance never can make good, and which, at the present time, in this country, equal ten times the losses in Europe in amount per capita.

DISCUSSION.

THE PRESIDENT. Mr. Barbour's paper is now before you for discussion.

MR. CHARLES E. CHANDLER.* I have been very much interested in Mr. Barbour's paper, and as discussion is perhaps best

* Civil Engineer, Norwich, Conn.

induced by some people taking the opposite side, I would say that, having occasion as chairman of a committee of the Connecticut State Board of Trade to meet insurance men comparatively recently, since the San Francisco fire, I take considerable interest in fire insurance. You remember that fire insurance rates, especially on mercantile property, were very largely increased a year or two before the San Francisco fire, and when that fire occurred the merchants and others had just got reconciled to those increased rates. Then the San Francisco fire stampeded the insurance companies, and they immediately made a large raise, 20 cents a hundred, in mercantile rates in what they called conflagration areas. That naturally raised a storm of protest, and committees were appointed from all sorts of trade organizations to treat with the insurance people. The result of it, or at least these committees claimed the result of it, was, that the companies dropped the 20 cents within a short time. They dropped it anyway, whatever the reason was, and perhaps they felt that they had made a mistake in having put it on at all.

But it seemed to be developed by conferences with the representatives of insurance companies that they had an idea that the fear of punishment was a better incentive to improvement in fire service than the hope of reward; at least it seemed as though that was the incentive they used generally. It also appeared that the idea of establishing rates on the principle of putting on all the traffic would bear was very generally followed. They admitted to us that Connecticut was one of the best states in New England in their past experience, that they derived more profit relatively from Connecticut than any other New England state, and when asked if we in Connecticut got better rates than they did in some other places, like Maine, for instance, they said, "We couldn't do business in Maine if we charged them as much as we charge you." [Laughter.]

MR. ALLEN HAZEN.* It seems to me that this question of fire protection and insurance rates is one that will solve itself in our cities during the next generation. The solution will come by the adoption of better methods of building. Concrete masonry floors will take the place of the wooden floors that are so com-

* Of Hazen & Whipple, Consulting Engineers, New York City.

monly used at the present time, and the change already beginning is bound to go on at an accelerated rate. This change and other improvements in building methods will bring us to the condition which has already been reached in some European cities, where the fire risk is so slight that it is not worth while to insure buildings and it is not worth while to lay the pipes of the water-works system larger than would otherwise be needed, in order to provide fire protection. In other words, the pipes are provided simply for the distribution of the water for domestic purposes and not for its concentration in large quantities on fires. This condition is bound to prevail ultimately with us, and it may come sooner than we now think. In the meantime, we have thousands of wooden buildings and buildings with wooden floors in all of our cities, and we must take care of them, for we cannot afford to lose them now, and while they last provision must be made for concentrating large quantities of water upon the fires that will inevitably take place in them, in order to prevent the spread of those fires with the destructive results which have been experienced too frequently by our cities.

The cost of providing the pipes and facilities for supplying this water from time to time in large quantities is very great. Some one must pay for it, and I believe that the more the expense of doing it can be put upon that class of buildings for which it is alone necessary, and the more that can be done to relieve from the tax the buildings that are fireproof, or substantially so, and do not profit by the service, the better it will be for the water departments and for our cities.

PRESIDENT MARTIN. I think when that time comes, Mr. Hazen, the school department of the city of Springfield, Mass., will throw up both its hands and require us to furnish all the water we can furnish for running motors. They advance the argument now that we have plenty of water standing idle in the pipes, and say, "Nobody wants it, why can't we use it?"

MR. LEONARD METCALF.* It seems to me that the remarks of Mr. Chandler but give point to some of the suggestions which Mr. Barbour has made as to the responsibility of water works officials to see to it that the ball is started rolling in the effort to get re-

* Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

duced insurance rates after radical improvement of the fire protection service. One of the difficulties, of course, in obtaining recognition from the city — the different departments of the city — for the benefit of the water department comes about from the intrusion of politics into the management of city affairs, and also from the desire of the different departments to make as good a showing as they can, so the water department has to bear the burden of making the improvements without getting corresponding recognition. The reduction in the insurance rates unfortunately does not go back to the city treasury nor to the water department, but to the individual, and so perhaps naturally it comes about that the water department postpones making improvements, which it recognizes should be made under existing conditions, in any particular city, until such times as the rates will enable them to do it, although they recognize perfectly well that the improvement should be made and that the saving in insurance rates would largely exceed the interest and other charges of the improvement.

Along this line I have been much interested in two or three cases which have come to my personal notice, following upon the taking of the water companies' property in certain places in Maine, in which water districts had been formed and the properties of the local companies taken over. In several of those cases, at least, the works have been virtually rebuilt, larger mains have been put in, and the fire service has been very materially improved. In some cases there has followed a reduction in the insurance rates. In those cases, under the Maine law, the department is operated as any corporation would be, independent of the city, the revenues being derived from the rates. But the city itself has not availed itself of the opportunity to get improved fire service by the placing of additional hydrants upon the system. In one case, for instance, at Waterville, Me., I remember we recommended that, owing to the distance apart of the hydrants, something like fifty hydrants be placed upon the existing and the new mains, at a nominal cost to the city. The result was, as I remember it, that they placed at first six hydrants and subsequently three more. As a matter of fact, the entire expense of the improvement was caused by the recognition of the fire district

trustees of their responsibility in the matter — their responsibility to furnish the city with a proper fire service — and yet the city officials, or the city council, was not willing to recognize the work to the extent of availing itself of the improved service. This difficulty has been obviated in some measure by offering, for a certain small nominal increase in rental, to place any number of additional hydrants which the city might desire upon existing mains, at the bare cost of placing them there. That perhaps is one step in advance of the old condition, but it is not a fair recognition of the work which the water department has done. I should suppose that competitive conditions in insurance would tend to bring about a reduction in insurance rates after an improvement of the service, but Mr. Chandler's remarks give point to the fact that even that influence does not always work.

THE ADJUSTMENT OF DIVERSION DAMAGES BY STORAGE COMPENSATION.

BY ROBERT E. HORTON, HYDRAULIC ENGINEER, ALBANY, N. Y.

[*Read September 24, 1908.*]

DEFINITION.

Storage compensation, or "compensation in kind," may be defined as regulation of the flow of a stream in such a manner as to compensate for water diverted, by drafts from storage during dry times, in such a manner that the flow of the stream shall never fall below a certain minimum fixed by agreement or adjudication. Such compensation would be furnished in lieu of, or in addition to, money damages for the diversion of water.

ENGLISH PRACTICE.

Compensation in kind apparently originated in England, although I have been unable to find the place or date of its origin. Clemens Herschel, who has given much study to the matter, says that for a hundred years or more this has been and yet is the accepted method in Great Britain. In England the use of compensation in kind in lieu of money damages may be determined upon by an act of Parliament in any case. The act, or a Parliamentary commission sitting as a court, fixes the rate of compensation as some fraction of the available flow. It is customary to deduct one sixth from the total yield of the stream to allow for freshet flow, which it is impracticable to store or utilize. The remaining five sixths is considered as the available flow, and the conditions of compensation require that the stream shall be so regulated that the flow shall at no time be less than a given fraction of the available flow. Humber says: "Mills are never designed to utilize the whole of the water flowing down a stream; by far the larger portion runs to waste, partly in times of excessive rain, and partly when the mills are not at work. The proportion of water utilized necessarily varies in different cases, and it is upon

this point that most of the contention between the promoters of water works and the owners of mills arises. It is ordinarily found that mills are capable of using only from one fourth to one third [of the available flow], and one or other of these proportions, mostly the latter, is generally assigned as the quantity to be passed uniformly and constantly down the stream as compensation." In a characteristic manner the English have reduced this matter to simple but rather arbitrary rule. English practice in compensation varies somewhat from the one-third rule, however, as illustrated by the following examples, collected from Tudsbury and Brightmore's "Water Supply Engineering":

City.	Stream.	Rate.	Date.	Remarks.
Liverpool	Vyrnwy	One-quarter	....	Industries unimportant
„	Rivington	One-half	1847	
„	„	About one-third	1868	Reduced by purchase
Manchester...	Longendale	Two-fifths	1848	Important industries
„ ...	„	One-third	1854	Reduced by purchase
„ ...	Thirlmere	About one-tenth	1879	

It will be noted that in two cases the original compensation rate has been subsequently reduced by purchase because the drainage basin was incapable of supplying both demands in full; thus the prime object of compensation in kind has been in some degree nullified.

Obviously there can be no uniform basis for compensation in kind that is applicable to all streams and which is just. The basis and method of compensation should differ according to the variability of the stream, the cost of storage development, the amount of storage which it is feasible to develop, the extent and character of the power development, and the amount of diversion to be made. The general principle may be laid down that for each business and water-power site there is some particular size of development that will yield a larger return per dollar invested than any other size. Any development that does not exceed this limit is a reasonable development, and the basis of compensation should be such as to do it no injury, even though it may require a higher basis of compensation than any other power on the stream.

DIFFICULTY IN EMPLOYING "COMPENSATION IN KIND" IN THE UNITED STATES.

The reason why compensation in kind cannot be made a legal remedy in the United States is that, under the Constitution, property cannot be taken without just compensation, and the United States Supreme Court has ruled that just compensation can only be measured and properly rendered in money.

I do not want to be understood as favoring the compulsory acceptance of compensation in kind as a legal remedy for diversion. There is little doubt that its adoption in this country on the same basis as in England would work a grievous injury to one of our greatest natural resources, — water power.

I believe that compensation in kind by mutual agreement is in some cases the best and cheapest method of adjusting diversion damages. If a prospective water supply would only injure a single riparian owner, it would more often be possible to adjust diversion damages by storage. It is usually the case, however, that a number of mill owners with a wide diversity of interests are to be dealt with, and the real difficulty is to secure concerted action among them. The same difficulty arises in the development of storage, in attempts to substitute central power stations for the wasteful system of distribution of power by hydraulic canals in the old mill towns, and in the development of irrigation and drainage projects. In the case of the two last named, legislation has been adopted in many states by which the will of the majority rules the community as a unit in the execution of such works. If legislation is adopted whereby all may be compelled to join in projects for the regulation of streams by which all will be benefited, a legal difficulty in the way of equitable adjustment of damages by stream diversion will be removed.

Frizell, in his "Treatise on Water Power" (pp. 539–540), suggests a form of law such that no one should be compelled to join in a storage project, but any one failing to pay for such storage should be required to pass down stream unused a quantity of water equal in amount to that fed into the stream from storage.

Such a law would aid to secure the coöperation of such persons as will, under present conditions, hold off in hope of securing the

benefit without payment; and who also, in case of diversion, might secure money damages and at the same time benefit by the compensation reservoirs built to indemnify their less swinish neighbors.

THE NEWTON, N. J., CASE.

In this case, as described by Mr. Louis L. Tribus, a lake was raised 5 feet and the mills were given full control of the resulting storage. They did not release the parties making the diversion, however, and although benefiting by storage and suffering no actual reduction in their power, they brought suit to recover for the diversion made. The court awarded damages of $3 302 for 2.65 continuous horse-power in one case, and $2 650 for 2.54 continuous horse-power in another case. These awards were made on the basis of capitalized cost of substituting steam-power. The higher court reduced the awards to $500 for 2.54 horse-power and $750 for 2.65 horse-power, the new awards being based on the difference in the value of the property before and after the diversion.

Clemens Herschel states that compensation reservoirs were actually built about sixty years ago in connection with the first Cochituate water works of Boston, but could not be used under American laws. I presume that there are other instances where compensation in kind has been used or attempted in this country to which my attention has not been called, and I believe those having the data of such cases should place them on record before this Association.

AN EAST CANADA CREEK CASE.

Power is developed at Beardsley Falls, on East Canada Creek, N. Y., under a head of about 120 feet. The city of Little Falls derives its water supply in part from Spruce Creek, a tributary entering East Canada Creek several miles above the power plant. After considerable litigation the matter of diversion damages was settled out of court, the writer being consultant to the power interest.

The city is allowed to take water from Spruce Creek without restriction upon condition that it shall perpetually pass down stream from its storage reservoir at Salisbury a depth of 3½ inches

at least, on a weir 18 feet long. This corresponds to 9.36 c. f. s. The intention was to provide an ultimate water supply of 6 000 000 gallons per twenty-four hours for the city, which also amounts to

MAP SHOWING COMPENSATION RESERVOIRS ON BLACK RIVER.

about 9.36 c. f. s. The tributary drainage basin of Spruce Creek is 36.2 square miles.

COMPENSATION IN KIND ON BLACK RIVER, N. Y.

The summit level of Erie Canal at Rome is about 25 miles south of the point where the Black River emerges from the southwest slope of the Adirondacks. Black River Canal extends northerly from Rome, connecting the Erie Canal with the navigable portion of Black River below Lyons Falls. Black River Canal also serves as an important feeder of the Erie summit level, supplying it with water diverted from Black River at Boonville. The geographical relations are shown on the accompanying sketch map (page 338).

There are numerous water powers along Black River from Carthage to its mouth, many of which were in use before the original diversion was made in 1849. The Boonville feeder was constructed to carry 267 c. f. s., but the natural minimum flow of the river at Forestport, which is the point of diversion, is only about 117 c. f. s., and during dry times, before the reservoirs subsequently described were constructed, practically the entire flow was diverted. Part of the diversion passes northward, supplying Black River Canal from Boonville to Lyons Falls, where it again enters Black River, and the remainder is permanently diverted, passing southward through Black River Canal and entering the Erie Canal at Rome. As soon as the Boonville feeder was put in use, complaints arose from mill owners, and claims for damages were filed. Part of Black River was, however, a navigable stream and a part of the state canal system, and the question arose and has never been decided, whether the state might not have taken such waters as it needed for navigation purposes without being held liable for damages. Precedent indicated that remuneration might only be obtained through the legislature. It was clearly the policy of the state to protect the industries along its canals, and accordingly Chapter 181 of the Laws of 1851 was enacted, providing for examinations of reservoir sites on Black, Beaver, and Moose rivers, directing the construction of, and appropriating money for, "reservoirs of sufficient capacity to supply the Black River Canal feeder with such quantity of water during the summer months as shall be necessary for the supply of Black River and Erie canals, and as shall give to the Black River, as near as may be, as much water as ordinarily flows therein during the summer months."

Apparently this basis of adjustment was quite satisfactory to a

majority of the riparian owners, although the delays incident to carrying out the provisions of the law caused further trouble. While I have seen no record to that effect, I have reason to believe that this act was drawn at the instance of the riparian owners, and to meet their wishes, and that this mode of compensation was not forced upon them.

The first reservoir was not completed until ten years after the feeder was put in use. Other reservoirs have been completed from time to time, the system at present being as shown in the subjoined table.

STORAGE AND COMPENSATION RESERVOIRS ON BLACK, BEAVER, AND MOOSE RIVERS.

Number on Map.	Name.	Tributary Area, Square Miles.	Approximate Storage Capacity, Cu. Ft.
	BLACK RIVER.		
1	Forestport Pond	86.46 (*a*)	13 068 000
2	" Reservoir	106.48 (*b*)	213 444 000
3	North Lake	27.76	301 653 000
4	South Lake	5.97	421 312 000
5	Twin Lake	4.77	68 607 000
6	Canachagala Lake	2.08	139 392 000
	WOODHULL CREEK.		
7	Woodhull Lake	9.40	876 601 000
8	Sand Lake	3.00	239 928 000
9	Chub Lake	9.87	34 848 000
	MOOSE RIVER.		
	Fulton Chain of Lakes.		
10	1st to 5th	35.23	352 000 000
11	6th to 7th	17.78	300 000 000
	BEAVER RIVER.		
12	Beaver	153.00	900 000 000
	Total	461.80	3 860 853 000

(*a*) Woodhull Creek, not including Black River.
(*b*) Not including Woodhull Creek.

The present average diversion, taken from the mean of many measurements, is as follows:

Flow in feeder, near mouth.....298 c. f. s.
Northward flow, returned to river ..... 79 „
Southward flow, diverted.....205 „

This apparently is a notable instance of compensation in kind on an unusually large scale, and comprising some peculiar features.

Two sets of reservoirs are provided, one to increase the supply that may be diverted, to an amount greater than the minimum flow; the other set for compensation. Originally the control of all the reservoirs was vested in the Canal Commissioners, but in 1896 a law was passed giving a commission of three water-power users complete control of all compensation reservoirs.

The law of 1851 failed to specify how many reservoirs should be constructed. The natural result has been a continued struggle on the part of the mill owners to have the reservoir system extended. It appears, however, that not until recently has the reservoir system been adequate to comply with the requirements of the law. No reliable gagings were made in the early years to determine the low-water flow, and the water-power users have been disposed to magnify its amount. It has been commonly reported among the riparian owners that the minimum flow in the vicinity of Watertown is 2 000 c. f. s. I have conducted careful gagings of the stream for several years which show several low-water periods with a flow of only 800 to 1 000 c. f. s., with the reservoirs in operation.

A practical difficulty with so large a system lies in the necessity of placing some of the reservoirs at a distance from the point of diversion. In this case some of the reservoirs are on the Moose and Beaver rivers, tributaries that enter Black River at a distance below Forestport, and there is left an intermediate reach of the river on which there are some water powers that suffer the full effect of diversion and receive little compensation water.

A NEW TYPE OF COMPENSATION IN KIND.

Diversion from West Canada Creek for the water supply of the city of Utica is compensated under contracts with the Utica Gas and Electric Company, owners of the Trenton Falls power plant, and the International Paper Company, which controls the so-called Herkimer hydraulic canal. These are the largest water-power users on the stream, the development being as follows:

	Drainage Area, Sq. Mi.	Head, Feet.	Approximate Turbine Cap.
Trenton Falls.....	375	265	333
Herkimer.....	583	30 to 33*	385

*At upper or paper mill level; 12 to 15 feet additional fall on lower level.

The principal provision of the contracts is to the effect that the Water Company may divert, without compensation, from any excess flow over the amount required by the plants in question. The Water Company may either divert such water directly or impound it in storage reservoirs for use in times when the natural flow does not exceed the requirements of the mills. This apparently simple arrangement is, so far as the writer is aware, the first of its kind. It has been in use two years and is found to be practicable to carry out in operation.

The conditions to be met were as follows: The Gas and Electric Company contemplated a progressive scheme of power development in which the construction of storage reservoirs as a private enterprise forms an element. The Water Company, on the other hand, desired that the amount of its diversion should be without restriction. It is believed that both of these requirements are satisfied. In the first place the Water Company cannot take any water which would otherwise be actually used by the power interests; hence, if the capacities of the power plants are increased, the limit above which the Water Company can divert without compensation will simply be raised. In the meantime, the Water Company is enabled to divert above a lower limit, and in so doing it works no injury to the existing power development, but is itself saved the outlay for enlarged compensation reservoirs until actually required. It might at first appear that the power interests, by sufficiently extensive installation and storage, could practically prevent the Water Company from taking any water. As a matter of fact, the Water Company is definitely assured of an abundant supply for any reasonable future demand. This assurance rests upon the facts, first, that it is impracticable to completely regulate this stream by storage, and second, the Water Company controls storage sites sufficient for its own requirements with any reasonable basis of power development.

West Canada Creek is an excellent water yielder, situated on the southwest slope of the Adirondacks, where the moisture-laden winds from Lake Ontario precipitate the maximum amount of rain and snow. Gaging records for dry years indicate that with the present basis of power development it will never be necessary to compensate during more than one hundred to one hundred and

twenty days without opportunity to replenish the storage, and even so long a period of deficiency will probably occur on an average only a few times in a century.

It follows that by providing a storage capacity equivalent to say one hundred days' supply the Water Company is enabled to make perpetual diversion. The present diversion is 6 000 000 gallons per day, and will be increased to 10 000 000 gallons per day in the near future. Of course, no effort is made to secure identity of the diverted and compensatory waters. The compensation reservoirs may be located at any point in the drainage basin, but if remote from the water supply intake, a reasonable time allowance is to be made between letting down the compensation and making the diversion. The real purport of these contracts is that whenever the flow in the stream at either of the mills is less than the amount required for power, the Water Company, if it is diverting water at its intake, likewise turns into the stream an equal amount of stored water, so that there is no change or diminution at any time in the flow utilized by the mills. The contracts are thus entirely flexible as to the amount of power that may be developed, or the amount of diversion that may be made so long as the capacity of the stream is not exceeded. The Water Company is under bond for the fulfillment of its contract, and in case of its failure, the power interests have the same remedies at law as if no compensation had been attempted.

One feature of the system is the maintenance of accurate weirs and gages to determine both the inflow to and the outflow from the storage reservoirs, as well as the flow in the West Canada Creek above the Gas and Electric Company's plant, and again near the mouth of the stream, above the Herkimer mills.

Carrying out the provisions of these contracts costs the Water Company a moderate amount, but, on the other hand, the pecuniary value of the compensation may be judged from the fact that the diversion of 10 000 000 gallons per day under 265 feet head, as utilized at Trenton Falls, would represent the destruction of 325 net horse-power.

The contracts were drawn jointly by several attorneys of experience in matters of water rights, with the assistance of the writer.

CONCLUSIONS.

1. Compensation in kind should not be attempted on a stream where the natural low-water flow plus the feasible storage development will not supply more than the total requirement for water supply and power.

2. Arbitrary rates of compensation should be avoided. The basis of compensation should be made so flexible as to admit of the best utilization of all the water of the stream in the most economical manner.

3. Legislation should be secured by which the will of the majority of riparian owners can be enforced in the matter of storage development and stream regulation, and which will prevent a minority of the riparian owners from either blocking a storage or compensation project, or from receiving benefits therefrom for which they do not pay.

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Tribus, Louis L.: *Engineering News*, April 5, 1900, pp. 228–229, describes conditions in Newton, N. J., case, and gives full text of decision.

DISCUSSION.

MR. CHARLES W. SHERMAN* (*by letter*). Reference has so often been made to the attempts to furnish "compensation in kind" in connection with Boston's Cochituate Water Works, that an authoritative statement of just what steps were taken and of the results

* Principal Assistant Engineer, with Metcalf & Eddy, Consulting Engineers, Boston, Mass.

obtained may be of interest, especially as the information is not readily available to many. The following data from Bradlee's history of the Boston Water Works * are accordingly submitted:

" The purchase of White Hall Pond, in Hopkinton, was made November 4 [1846], by the Committee on Water, under the resolve passed April 21, . . . for the sum of $25 000, with the intention of using it as a Compensating Reservoir to flow into the Concord River as a substitute for Long Pond water, whenever that should be diverted from its natural channel to the injury of those who were entitled to the use of it." . . . "The actual cost of this Reservoir, after the dam was built and the improvements made, was $29,534.36." (Page 100.)

" At this time [December 13, 1847], the [Water] Commissioners thought it best to build Compensating Reservoirs, to serve as a substitute for the waters which might be diverted from Concord River, and at their request the following order was passed [by the City Council]:

"*Ordered;* that the Water Commissioners be authorized to make such purchases of lands and water rights in the name and on account of the city of Boston, and to erect such dams, embankments, and other works, as they shall deem necessary and expedient for forming Reservoirs of water to serve as a substitute for the waters which may be diverted from Concord River, and to make payment therefor, in the same manner as for lands and water rights purchased by virtue of the act for supplying the city of Boston with pure water; *provided,* the same does not exceed the sum of fifty thousand dollars." (Page 71.)

" January 13, 1848, the Commissioners purchased of Mr. Amory Maynard, the Marlborough and Boon Pond Reservoir, for the sum of $21 148.90; they finally cost, however, when the dam was completed and the reservoir ready for use, $43 170.59." (Page 109.)

In 1854, the Whipple suit for damages for diverting the waters of Lake Cochituate from Concord River was brought, and resulted in the settlement of all claims for $6 678.90. (Page 170.) This seems to have demonstrated the futility of the attempt to furnish " compensation in kind."

" The Marlborough Reservoir was sold this year, July 29 [1858], to Mr. Amory Maynard, for the sum of $8 000." (Page 184.)

* N. J. Bradlee: "History of the Introduction of Pure Water into the City of Boston, with a Description of Its Cochituate Water Works." Boston, 1868.

In 1859, "the proprietors of Sudbury meadows . . . memorialized the city of Boston for payment for damage done their property by letting down water from the reservoir at unseasonable times." . . . The water board finally proposed that —

"The city of Boston will convey to some responsible agent or committee, authorized to act in behalf of the proprietors, by quitclaim deed, all the right, title and interest which the city possesses in and to the reservoir [Whitehall Pond], at Hopkinton, with its dam, gate-house, and flume, to have and to hold, and lawfully manage and control the same as they please." (Page 193.) This was done.

MR. LOUIS L. TRIBUS.* If I had known, Mr. President, that the Newton case was to be brought up here, I would have been very glad to have shown a map exhibiting some features, which were rather interesting in some respects. It is one of the few cases in this country where a reservoir has been actually constructed partially — not wholly, as the paper under discussion would seem to indicate — for the purpose of compensating in kind. The town of Newton, N. J., was not a riparian owner on the stream in question, so could only act through "agreements" rather than by "rights." On this stream there were three mills, neither one having storage capacity to supply other than a daily regulation of the mill use. The upper owner, about forty years or so before the Newton work was carried on, diverted a small stream from its natural course into an artificial pond made at the outlet of a natural lake, the combined flows later reaching the same original brook. Many years ago the level of the lake was raised slightly by a small earth dam, but this, following construction of the lower pond, was allowed to practically disappear so that the waters of the pond and lake were reasonably free to flow back and forth. This upper owner used at will the natural flow of the stream and the outflow from lake and pond, without regard to the interests of the lower owners who had no interest, through ownership, of any pondage along the upper stream.

Newton bought some of the rights of this upper owner and the fee in the original lake. It fully diverted the upper stream, the one that this original owner had partially diverted into the upper lake, and erected a substantial masonry dam, raising the high

* Consulting Engineer, New York City.

water level some five feet. In that upper five feet there was stored at least twice as much water as would suffice the uses of the town of Newton for a whole year, and that upper five feet could easily be stored in two days' flow of an ordinary winter or spring storm from the direct and diverted watershed. In fact, it has been filled in about twenty-four hours.

The speaker, as engineer for the town, urged the commissioners to enter into written agreements with the lower mill owners. They thought, however, that in view of the expenditure that Newton was incurring for raising the level of the upper lake and the general friendly feeling for the enterprise, there would be no need of an agreement, as there were no actual physical damages, but, instead, betterments. The agreement with the upper owner was such that he was to control the gate of the lower pond at will, and the town was to feed the lower pond from its stored waters as he should require, keeping the water level in the lower pond practically at a standard.

The lower owners made no objection, the works were built, and things went on for nearly two years, the mills all receiving a distinct benefit; but then suits were brought, and the court decided, on the old principle of law, that damages must be recognized in money and that theoretically (it could not say practically, because there was no practical damage) these owners were deprived of the amount of water that Newton could take through its mains out of the watershed into another watershed; therefore, it was the flow of a 10-inch pipe (the main line) for twenty-four hours for 365 days in the year which must be made the basis of an award for damages. The upper owner from whom much of the property had been purchased had grace enough not to bring any suit at that time. He, however, did bring a suit later which, after a lengthy trial, was settled out of court for a small sum. He ought never to have won in view of the special considerations in his case, but the court would probably have awarded damages on the technical questions involved rather than actual damages incurred.

MR. ALLEN HAZEN.* I am under the quite distinct impression that the city of Fitchburg, Mass., has compensated mill owners

* Of Hazen & Whipple, Consulting Engineers, New York City.

in kind, and built a reservoir and turned it over to the mill owners, to be operated in lieu of water diverted from other tributaries of the stream for uses of the city; but it is my impression that that arrangement was carried out by agreement and could not have been carried out in any other way. I do not want that to be taken on my statement, but some one should make a definite statement of it and it should go in the record, I think, in connection with these other cases.

MR. THOMAS H. MCKENZIE.* I happen to be familiar with one instance in which compensation in kind has been made, at Meriden, Conn.; that was partly by agreement and partly by legislation. All of the mill owners agreed to a certain size and capacity of reservoir in lieu of money damages, and the city of Meriden secured legislation authorizing the construction of the compensating reservoir and the issuing of bonds to cover the cost, and I believe the arrangement has worked very satisfactorily. That is the only case which has ever come to my knowledge.

MR. HAZEN. I think, Mr. President, if the principle could be established there would be many cases where developments would be possible that are not considered possible under present laws, and that great good might come from it both to some of our cities and also to manufacturing corporations upon rivers.

MR. LEONARD METCALF.† Mr. President, just to get the matter on the record, it may be well to mention that I think something of the sort was done by the mill owners on the Blackstone River, — I should have said the Draper Company took the initiative in the matter, — and they built a dam at North Pond for storage purposes solely. I think that Arthur T. Safford, of Lowell, will probably know the facts in regard to the matter, so it can be looked up in connection with this paper.

MR. DAVID A. HARTWELL ‡ (*by letter*). In 1891 the city of Fitchburg was greatly in need of an additional water supply, and two natural ponds in the town of Westminster seemed the most desirable of any possible source. These were Meetinghouse Ponds with a water surface of 152 acres and a watershed of 942 acre (including the pond), and Wachusett Lake, partly in Westminster

* Consulting Engineer, Southington, Conn.
† Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.
‡ City Engineer, Fitchburg, Mass.

and partly in Princeton, with a water surface of 134 acres and a watershed of 976 acres (including the lake). Franklin Wyman owned and operated a paper mill at what was called "The Narrows," and controlled the waters of Meetinghouse Pond and Wachusett Lake. He also had a storage reservoir called Wyman reservoir above his mill, with a watershed of 3 032 acres in addition to the water sheds of Meetinghouse Pond and Wachusett Lake, the overflow from which enters said Wyman reservoir. The dam of the Wyman reservoir was in such poor condition in 1891 and for some years previous thereto that the county commissioners would not allow him to fill it.

The city of Fitchburg purchased of Mr. Wyman, for $75 000, all his storage and flowage rights, his paper mill and adjacent houses and other buildings and a considerable area of land. Section 4, Chapter 60, of the Acts of 1892 of the Massachusetts Legislature relative to an additional water supply for the city of Fitchburg reads as follows:

"Said city is also authorized to take and hold, by purchase or otherwise, the water of Wyman reservoir, so-called, in the town of Westminster, and the waters which flow into and from the same, and any water rights connected therewith, to be used as a compensating reservoir for all damages that would otherwise arise to mill owners by reason of the taking and diverting of the waters of Meetinghouse Pond and Wachusett Lake; and to take and hold in like manner such lands as may be necessary for building, erecting, and maintaining a dam for storing and distributing said waters. Said city is authorized to contract with mill owners whose rights are affected, in relation to the manner and mode of using, controlling, and operating said compensating reservoir."

Acting under this section the city built a new dam for the Wyman reservoir so as to store up to the limit of the flowage rights, which raised the level of Wachusett Lake about four feet. The cost of this dam, including the gate house and contingent work, was about $50 000. This compensating reservoir, not including Wachusett Lake, has an area of 203 acres and an available storage of 419 000 000 gallons.

An agreement was made with all the mill owners on the north branch of the Nashua River and the mill owners on the main river between the junction of the north and south branches at Lancaster

and its confluence with the Merrimac at Nashua. By this agreement the mill owners released all rights to the waters of Meetinghouse Pond and Wachusett Lake and the city built the Wyman dam. That part of the agreement relating to said Wyman reservoir reads as follows:

"Now, therefore, the said city hereby covenants and agrees with the said parties of the second part, and with each of them, their heirs, executors, administrators, successors, and assigns, that it will forever maintain said reservoir at its present capacity for the sole use and benefit of said parties of the second part, their heirs, executors, administrators, successors, and assigns, and that it will take whatever measures are necessary to prevent any interference with, or diversion of, the waters which flow into the same and the sources of supply by which the same is filled, and that it will forever keep the walls and gates of said reservoir in good repair so that the water thereof, and no part thereof, shall be allowed to escape except as hereinafter provided, and that it will forever keep and maintain in good repair the dam now located at the eastern end of said reservoir at its present height and that it will construct and forever maintain at the eastern end of said reservoir a proper gate or gates to control the waters of the same, and that it will always supply and employ a suitable man, or men, at its own expense, to care for said gate, or gates, at said dam, and to so adjust the same that there shall be as nearly as possible an uniform flow of water, each and every day, except Sundays and legal holidays, throughout each and every year hereafter, into the natural channel as it exists to-day, and to so adjust the said gate or gates that said flow of water shall be as great as possible consistently with the uniform flow thereof; that it will permit none of the waters of said reservoir to be used for any other purpose than is herein provided, and that the said waters of said reservoir shall at all times when said gates are open flow unused and without interruption of any kind into the said channel, and shall be used for no other purposes except as a part of the waters of the Nashua River after they shall have gone into the said stream, except, however, and it is hereby expressly provided, that it shall be lawful for the city in case a serious conflagration occurs in West Fitchburg, or in the city of Fitchburg proper, or in case the pipes which carry the waters of Wachusett Lake and Meetinghouse Pond into the city of Fitchburg shall break above the said Wyman's reservoir, to draw the waters of the said reservoir into the pipes which form the city's system of water supply, during the existence of said conflagration, or until the said break shall have been repaired by due diligence on the part of the city."

Thus the city of Fitchburg, with an expense of about $125,000, purchased water rights and settled all claims for loss of power by which, under proper development, was made available an additional supply of about 4 000 000 gallons a day.

MR. T. H. MCKENZIE (*by letter*). I happen to know of one instance in which compensation in kind was made by the city of Meriden, Conn., to the mill owners on Sebethe River in the town of Berlin, in the year 1868.

The city of Meriden diverted the water from one square mile of watershed which was tributary to six mills which were in operation and one mill privilege not in operation. The fall at the privileges in operation was about as follows: 18, 14, 36, 12, 8, and 8 feet; total, 96 feet fall. The compensating reservoir cost $18,000, which is equivalent to $187.50 for each foot fall for one square mile of watershed.

This settlement was by agreement with the mill owners to accept a certain size and capacity of reservoir in lieu of money damages, and afterwards by the city of Meriden securing legislation authorizing the taking of land and the issuing of bonds to cover the cost of construction. The reservoir is of 52 000 000 gallons capacity. The arrangement worked satisfactorily for many years.

At the time the reservoir was built, three of the falls, 18, 36, and 12 feet, respectively, were owned by one company; this same company owned property below the compensating reservoir, and above all of the mills another storage reservoir of double the capacity of the compensating reservoir. The water from the compensating reservoir had to pass through this large reservoir before reaching the factories. The company owning the three falls of 18, 36, and 12 feet, by common consent of all of the mill owners, controlled the gates at the compensating reservoir as well as the other large storage reservoir. In course of time the large company sold the mill with the 12-foot fall, but did not sell their rights in the large storage reservoir. Then trouble began to brew. The owner of the large powers who controlled the gates drew all of the water from the compensating reservoir and still held the water in their storage reservoir. The large company found it necessary to shut down their factories for a month in July, when the party below with 12-foot fall wanted to run; very little water was running in the

stream, not enough to run a mill, so a suit was brought against the large company to compel it to let water down. The large company claimed that the water was all drawn from the compensating reservoir and that the water in the large storage reservoir below all belonged to them as it was stored water from the spring floods. The large company won in the suit, and held the water.

Aside from this one incident, the plan of compensating in kind might be called a success in this case, although if one of the proprietors of the mills wished to put his property to other use than for power purposes, the stored water would be of little use to him, while the money would be useful and would be drawing interest.

As to the saving in the Meriden case, it is somewhat doubtful about any saving in cost. The cost of the reservoir in the Meriden case was about $187 per foot fall for one square mile.

The cost in a large number of cases in which I have been engaged and where money damages were paid ranged from $100 to $210 per foot fall per square mile of watershed diverted. This price refers to mill powers which are actually developed and in operation. In the Meriden case, the cost of the compensating reservoir figures about $200 per foot fall per square mile of watershed diverted.

Where a large number of mills are to be settled with on a stream it would be much cheaper to settle by storage of water.

Where only a few mills are to be settled with and a small area of watershed is diverted, it would be cheaper to settle by paying money for damages.

I doubt, however, about any general law being enacted that will compel the claimants to accept something in lieu of money for damages.

The matter of drawing off the water and controlling the gates of a storage reservoir which is owned in partnership is a difficult problem to handle. One party may want to run his mill and another want to shut down his mill and save the water.

I had occasion a few years since to make surveys and plans for a large storage reservoir on the east branch of the Farmington River in the town of Otis, Mass., for the Farmington River Power Company. There were originally seven equal owners in the company, which was organized for the purpose of building the first storage reservoir on this stream. After the reservoir was built two of the

owners, in order to control the gates at the storage reservoir, bought out the other five owners. When it came to the matter of deciding on the building of the new storage reservoir the seven mill owners were all called upon to take each one seventh of the stock. The five who had sold out declined to take, saying to the other two, "You are the Farmington River Power Company; you control the stock of the company and the stream"; so, of course, the second reservoir was not built. I mention this instance to show the difficulties of handling such partnership matters in the control of reservoirs.

MR. HORTON (*by letter*). Since this paper was prepared, I have been informed that an additional case of compensation in kind exists in New Jersey. Unfortunately, the details are not available further than that a system of compensation was established many years ago in connection with the taking of water from a lake or stream for the supply of navigable canals.

PROCEEDINGS.

June Outing.

Plymouth, Mass., June 24, 1908.

The June meeting of the New England Water Works Association was held at Plymouth, Mass., on Wednesday, June 24, 1908, with the following attendance:

Members.

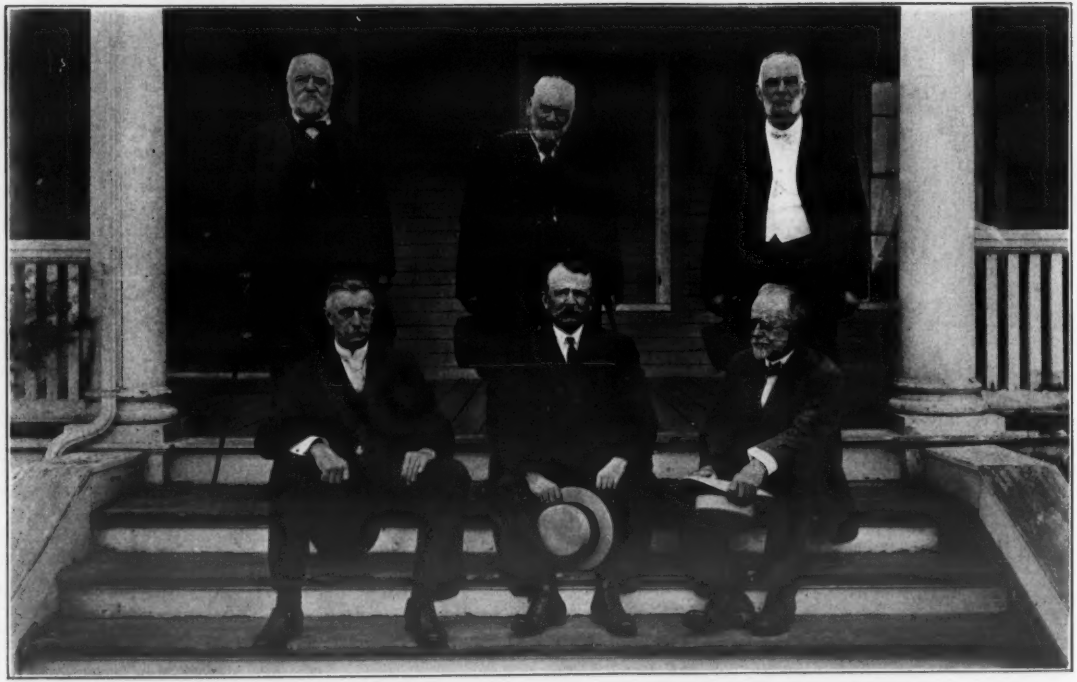
S. A. Agnew, R. W. Bagnell, Lewis M. Bancroft, Joseph E. Beals, Arthur E. Blackmer, James W. Blackmer, James Burnie, Charles E. Childs, John W. Churchill, Frank L. Clapp, R. C. P. Coggeshall, Michael F. Collins, George E. Crowell, John C. De Mello, Jr., Edward D. Eldredge, Charles R. Felton, John N. Ferguson, Arthur N. French, Albert S. Glover, Frank H. Gunther, Frank E. Hall, Horace G. Holden, Willard Kent, George A. King, A. R. McCallum, Hugh McLean, A. E. Martin, John Mayo, Leonard Metcalf, Frank L. Northrop, J. K. Nye, Oren E. Parks, William H. Pitman, Leonard C. Robinson, Henry W. Sanderson, A. L. Sawyer, Walter H. Sears, Edward M. Shedd, Charles W. Sherman, William E. Smith, Harry L. Thomas, Robert J. Thomas, William H. Thomas, James L. Tighe, D. N. Tower, Charles K. Walker, Lettice R. Washburn, Robert S. Weston, John C. Whitney, L. J. Wilber, George E. Winslow. — 51.

Associates.

Anderson Coupling Company, by Charles E. Pratt; Builders Iron Foundry, by A. B. Coulters and F. N. Connet; Chapman Valve Manufacturing Company, by Edward F. Hughes; Hersey Manufacturing Company, by Albert S. Glover; International Steam Pump Company, by Samuel Harrison; Lead Lined Iron Pipe Company, by T. E. Dwyer; Ludlow Valve Manufacturing Company, by A. R. Taylor; H. Mueller Manufacturing Company, by George A. Caldwell; National Meter Company, by J. G. Lufkin; Neptune Meter Company, by H. H. Kinsey; Pittsburg Meter Company, by F. L. Northrop; Rensselaer Manufacturing Company, by C. L. Brown; A. P. Smith Manufacturing Company, by F. N. Whitcomb; Thomson Meter Company, by Edw. M. Shedd; Union Water Meter Company, by F. L. Northrop. — 15.

Guests.

M. M. Garvey, Lawrence, Mass.; Miss Henrietta C. Walker, Manchester, N. H.; Mrs. A. S. Glover, Newton, Mass.; Mrs. F. H. Gunther, Dracut, Mass.; S. M. Spencer, Malden, Mass.; Mrs. Geo. E. Winslow, Waltham. Mass.;



THE SURVIVING CHARTER MEMBERS OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

(From a photograph taken at Plymouth, Mass., June 24, 1908.)

H. G. HOLDEN. R. W. BAGNELL. C. K. WALKER.
F. E. HALL. A. S. GLOVER. R. C. P. COGGESHALL.

I. M. Low, superintendent, Weymouth, Mass.; Mrs. J. N. Ferguson, Boston, Mass.; Miss Nellie Collins, Lawrence, Mass.; Mrs. L. J. Wilber, Brockton, Mass.; Mrs. F. N. Connet, Providence, R. I.; Mrs. A. E. Blackmer, Plymouth, Mass.; Mrs. Walter H. Sears, New York, N. Y. — 13.

[Names counted twice — 3.]

A business meeting was held at the Armory, where the Association was welcomed by representatives of the town, and the following were admitted to membership:

Dana M. Wood, assistant engineer, United States Geological Survey, Boston, Mass.; Frank A. Marston, civil engineer, with Metcalf & Eddy, Boston, Mass.; H. Lester Newhall, third assistant, city engineering department, Brockton, Mass.; Ira C. Forbes, mechanical engineer, West Shokan, N. Y.; Thomas Gray, manager High Falls Power Company, Ellenville, N. Y.; James F. Sanborn, assistant engineer, New York Board of Water Supply, 236 Main Street, Poughkeepsie, N. Y.; Nicholas S. Hill, Jr., consulting engineer, 100 William Street, New York City; Charles L. B. Anderson, consulting municipal engineer, Atlanta, Ga.; C. Sherman Rex, Jr., superintendent Creston Water Works Company, Creston, Ia.; Francis C. Hersey, Jr., water commissioner, Wellesley, Mass.; and Henry A. Young, chief engineer Camaguey Water Works, Camaguey, Cuba.

Most of the members then proceeded to the shop of the Plymouth Water Works on Howland Street, where the construction of the Phipps cement-lined and jacketed pipe, which is exclusively used in Plymouth, was witnessed, and the process was fully explained by Supt. A. E. Blackmer.

Pilgrim Hall and other places of interest were visited by a number of the party. Special electric cars were then taken to Hotel Pilgrim, where luncheon was served and where a photograph was taken of the surviving charter members of the Association, Messrs. H. G. Holden, R. A. Bagnell, Charles K. Walker, Frank E. Hall, A. S. Glover, and R. C. P. Coggeshall. [This photograph is reproduced herewith.] Many of the party then visited the water works pumping station and inspected the work of laying the cement-lined pipe, which was in progress near by.

Twenty-Seventh Annual Convention, Atlantic City, N. J., September 23, 24, and 25, 1908.

The Twenty-Seventh Annual Convention of the New England Water Works Association was held at Atlantic City, N. J., on September 23, 24, and 25, 1908. The headquarters of the Association were at the Traymore Hotel, and the meetings were held in the Assembly Hall at the hotel.

The following members and guests were in attendance:

Members.

S. A. Agnew, Kenneth Allen, M. N. Baker, C. H. Baldwin, A. F. Ballou, F. A. Barbour, G. W. Batchelder, E. W. Bemis, C. R. Bettes, F. E. Bisbee, James Burnie, T. J. Carmody, C. E. Chandler, J. H. Child, C. E. Childs, W. F. Codd, W. R. Conard, G. K. Crandall, John Doyle, M. J. Doyle, E. D. Eldredge, G. H. Felix, B. R. Felton, J. H. Flynn, Murray Forbes, F. L. Fuller, W. B. Fuller, A. S. Glover, Wallace Greenalch, C. A. Hague, F. E. Hall, W. C. Hawley, Allen Hazen, G. T. Ingersoll, G. G. Kennedy, E. W. Kent, Willard Kent, G. A. King, J. J. Kirkpatrick, Morris Knowles, B. C. Little, E. E. Lochridge, F. H. Luce, F. A. McInnes, T. H. McKenzie, Hugh McLean, P. A. Maignen, A. E. Martin, G. F. Merrill, Leonard Metcalf, F. L. Northrop, H. N. Parker, E. M. Peck, E. L. Peene, T. A. Peirce, E. A. Pickup, A. A. Reimer, P. R. Sanders, W. J. Sando, A. L. Sawyer, E. M. Shedd, P. S. Smith, J. F. Sprenkel, L. A. Taylor, R. J. Thomas, J. L. Tighe, D. N. Tower, J. C. Trautwine, Jr., L. L. Tribus, J. H. Walsh, C. S. Warde, J. S. Warde, R. S. Weston, I. S. Wood, C. L. Wooding, Timothy Woodruff. — 76.

Honorary Member.

F. W. Shepperd. — 1.

Associates.

Allis-Chalmers Company, by W. J. Sando; Anderson Coupling Company, by Charles E. Pratt; Builders Iron Foundry, by A. B. Coulters and E. C. Atkins; Central Foundry Company, by J. H. Morrison; Chapman Valve Manufacturing Company, by Edward F. Hughes; The Fairbanks Company, by C. H. White, West DeHaven, and J. F. O'Brien; Hays Manufacturing Company, by T. J. Nagle and C. A. Eaton; Hersey Manufacturing Company, by Albert S. Glover, H. D. Winton, W. C. Sherwood, and W. T. Kershaw; International Steam Pump Company, by Samuel Harrison; Lead Lined Iron Pipe Company, by Thomas E. Dwyer; Ludlow Valve Manufacturing Company, by H. F. Gould; Charles Millar & Son Company, by Charles F. Glavin; H. Mueller Manufacturing Company, by George A. Caldwell, F. B. Mueller, O. B. Mueller, and F. W.

Cruckshank; National Meter Company, by C. H. Baldwin, John C. Kelley, W. P. Oliver, J. G. Lufkin, and Lewis H. Nash; National Water Main Cleaning Company, by D. H. Buell; Neptune Meter Company, by H. H. Kinsey, F. A. Smith, and C. A. Vaughan; Norwood Engineering Company, by H. W. Hosford; The Pitometer Company, by L. B. Shoemacher; Pittsburg Meter Company, by F. L. Northrop, T. C. Clifford, A. G. Holmes, and V. E. Arnold; Rensselaer Manufacturing Company, by F. S. Bates and C. L. Brown; Ross Valve Manufacturing Company, by Wm. Ross and Adam Ross, 2d; A. P. Smith Manufacturing Company, by F. N. Whitcomb and John W. Strachbeim; Thomson Meter Company, by E. M. Shedd, S. D. Higley, W. S. Cetti, and J. L. Atwell; Union Water Meter Company, by F. E. Hall; United States Cast Iron Pipe & Foundry Company, by F. W. Nevins and W. B. Franklin; Water Works Equipment Company, by Walter H. Van Winkle and W. H. Van Winkle, Jr.; R. D. Wood & Company, by Wm. P. Brew and Edward J. Lane. — 55.

GUESTS.

Joseph F. Biladeau, Pittsfield, Mass.; Mrs. Louis L. Tribus, Master Lucian Hall Tribus, Mrs. A. A. Knudson, Mrs. Fred A. Smith, Miss Bessie J. Warde, Mrs. Charles H. White, Mrs. Kenneth Allen, Miss Mildred Arnold, Mrs. F. W. Shepperd, Mrs. J. F. O'Brien, Miss Zada O'Brien, F. W. Stodder, Mr. Thomas Liston, Mr. I. S. Holbrook, Miss Leda Mueller, Mrs. F. W. Cruckshank, Mrs. H. Mueller, Mrs. Edmunds, Mrs. John C. Kelley, Miss Kelley, New York City; Mrs. A. E. Martin, Mrs. Clara A. Kilburn, Mrs. E. E. Lochridge, Springfield, Mass.; Mr. and Mrs. L. Van Gilder, Mr. Wm. H. Randolph, Miss T. Strauss, Mr. Stanley Johnson, Mrs. M. Somers, Miss S. Tilton, Miss Elsie Reuscher, Mrs. H. H. Decker, B. F. Souder, Miss C. May Chase, Atlantic City, N. J.; Mrs. T. A. Peirce, Mrs. Joseph W. Vaughan, East Greenwich, R. I.; Mrs. Francis H. Luce, Woodhaven, N. Y.; Mr. Albert Blauvelt, Chicago, Ill.; Mrs. A. A. Reimer, East Orange, N. J.; Mrs. E. C. Atkins, Mrs. I. S. Wood, Providence, R. I.; Mrs. John Doyle, Worcester, Mass.; Miss A. E. Nugent, Mrs. Albert S. Glover, Mrs. H. F. Gould, Mrs. John H. Flynn, Boston, Mass.; Mr. and Mrs. James P. Bacon, Cambridge, Mass.; Mr. M. J. Gray, Burlington, N. J.; Mr. James G. Hill, Mr. Patrick Kelley, Mrs. R. J. Thomas, Miss Katherine Walsh, Miss Charlotte Walsh, Lowell, Mass.; Hon. Horace S. Van Worst, Charles B. Pond, Schenectady, N. Y.; Mrs. John C. Trautwine, Jr., Mr. Joseph Thompson, Mr. George Costello, Mr. W. F. McCarthy, Philadelphia, Penn.; Mrs. Edward L. Peene, Yonkers, N. Y.; Mrs. T. C. Clifford, Miss Lois I. Clifford, Pittsburg, Penn.; Mrs. Murray Forbes, Greensburg, Penn.; Mrs. George H. Felix, Reading, Penn.; Mrs. George G. Kennedy, Harrisburg, Penn.; Mr. W. F. Penn and Miss Katherine Penn, Morganza, Penn.; Mr. Edmund T. Scott, Trenton, N. J.; Miss May I. Agnew, Mr. John J. Heavey, J. W. Griffin, Thomas Rooney, Hon. H. O. Wittpenn, Alex S. Hanult, and Edward W. Henry, Jersey City, N. J.; Mr. Frank S. Fithean, Camden, N. J.; Mrs. Small, Auburn, Me.; Miss Helen C. Doorty, Buffalo, N. Y.; Miss Mary A. Sargent, Cleveland, O.; Mr. R. W. Pratt, Columbus, O.; Miss Grace Merritt, San Fran-

cisco, Cal.; Mr. T. A. Collins, Lawrence, Mass.; Mrs. T. J. Carmody and Mrs. J. J. Kirkpatrick, Holyoke, Mass.; Mrs. Wm. F. Codd, Nantucket, Mass.; Mrs. D. N. Tower, Cohasset, Mass.; Mrs. F. A. McInnes and Miss Frances McInnes, Boston, Mass.; Mrs. Willard Kent, Narragansett Pier, R. I.; Mr. R. S. Kellogg, Mr. Alvan Donnan, Washington, D. C.; Mr. Frank Little, Mrs. David Little, Rochester, N. Y.; Mrs. O. B. Mueller, New Rochelle, N. Y.; Mr. John K. Guinn, Utica, N. Y.; Mrs. Charles R. Bettes, Far Rockaway, N. Y.; Mr. F. J. Deutschbeim, Albany, N. Y.; Mr. H. R. Beebe, Utica, N. Y.; Mr. T. D. Faulks, Newark, N. J.; Mr. and Mrs. Jas. Donovan, Middletown, Conn.; Mrs. Charles E. Chandler, Norwich, Conn.; Mr. Albert S. Sessions, Bristol, Conn.; Mr. Robert W. Grant, Woonsocket, R. I.; Mr. Peter J. Ford, Dr. A. Robin, Mr. John Keule, Wilmington, Del.; Mr. F. E. Puffer, New York City; Mr. and Mrs. James J. Griffin, Middletown, Conn.; Mr. Arthur W. Burnie, Biddeford, Me. — 113.

[Names counted twice — 6.]

Morning Session, Wednesday, September 23.

President A. E. Martin called the convention to order and spoke as follows:

Gentlemen of the New England Water Works Association and Guests, — It is hardly necessary for me to reiterate my statement of last January that I am proud to stand before you to-day as president of this Association, which includes among its members men of marked and proven ability in the profession of water-works construction and maintenance, men who are willing to give deep study and much time to the different subjects in which we are interested, and then bring before us, in well-written papers, ideas which benefit us all.

Many of those who organized this society have joined the silent majority, and their faces are much missed at our conventions, but the same spirit is manifest to-day that was shown twenty-seven years ago, when that little body of men first associated themselves together for mutual help and improvement.

I am pleased to greet you in Atlantic City to-day. For a long time many of our members have desired to hold a convention in this city, and to-day we see the fruition of those wishes.

To me it is somewhat of a red-letter day in another way, for besides being the opening day of this convention of our Association, it also marks the beginning of another lap on my life's journey. Something more than *twenty-seven* years ago, on the

twenty-third of September, in an old red brick farmhouse in the good old town of Brooklyn, Conn. (that land of steady habits and wooden nutmegs), at very early hour in the morning (so I am credibly informed), the interesting event occurred which made it possible for me to stand here to-day as your presiding officer.

I feel that I must digress here to say that my enforced early rising on that eventful morning undoubtedly prejudiced me against the practice ever after, for it has been only with a most unwilling spirit that I have ever indulged in such a luxury since.

But laying all jesting aside, it will always be one of the pleasantest incidents of my life that on this anniversary I had the pleasure and honor of presiding at the twenty-seventh annual convention of the New England Water Works Association.

I will not take up more of your time, for I know you are all anxious to hear another who is present and who, doubtless, considers it a pleasure as well as a privilege to greet you.

I take great pleasure in introducing his honor, Mayor Stowe, who will give you a welcome to this fair city by the sea.

Mayor Stowe. *Mr. President and Members of the Association,* — I assure you that it gives me great pleasure to come before you this morning, and I wish particularly to congratulate the President on his birthday. It must be very pleasant for him, especially if he has his family with him, and I hope that at least once in twenty-seven years they can all have a day of recreation at the seaside. I understand this is the first time that your Association has ever met in our city. I am surprised that a matter so important to you and to us has been left so long unattended to. [Laughter.] You gentlemen are engaged in an occupation for the benefit of humanity, and you should be looked up to with more appreciation, perhaps, than any of the rest of us who are engaged in municipal affairs, for it is your particular duty to see to it that we have good water. It has been my privilege during the past few years to appoint the water commissioners of our city, and I can say that for eight or nine years we have had a very efficient board. As you know, here on the seashore we cannot get our water from driven wells, and there is no fresh water stream, and we are compelled to go to the main land for our supply. I can assure you that you can drink our water here with the certainty that you are drinking

something that cannot be equaled in the shape of water within a radius of at least two or three hundred miles.

We are proud to have you with us, and we hope to receive much benefit from your visit. We bid you welcome and extend to you the freedom of the city. I trust that you will feel at liberty to make all the investigation and inquiry into our affairs — to "butt in," if you please — that you desire; and we will be ready to listen and learn anything you can tell us which will better our condition, for certainly this body must possess a great deal of valuable information on the subject of water supply.

Now, Mr. President, as you know, our city is going through a rather strenuous ordeal in certain directions [laughter], and as I was not able to get to bed at all last night, I trust you will excuse me from making any further remarks. I will, therefore, close by repeating that I want you to feel free to do just as you please here, to feel that you belong to us as long as you stay here, and if I can be of any service to you at all I shall be only too happy. I thank you for this opportunity to speak to you. [Applause.]

THE PRESIDENT. I can assure you, Mr. Mayor, that the Association appreciates your welcome and will be glad to accept your courtesies.

On motion of Mr. George A. King, it was voted that the President be authorized to appoint a committee of five to nominate officers for the ensuing year. The following-named gentlemen were appointed as the committee: J. C. Whitney, Newton, Mass.; Leonard Metcalf, Boston, Mass.; George A. Stacy, Marlborough, Mass.; E. W. Kent, Woonsocket, R. I.; William F. Sullivan, Nashua, N. H.

Mr. John C. Trautwine, Jr., civil engineer, Philadelphia, Penn., read a paper on "Water Purification at Philadelphia," illustrated by lantern slides.

Adjourned.

AFTERNOON SESSION, WEDNESDAY, SEPTEMBER 23.

President Martin in the chair.

The afternoon session was devoted to a consideration of the subject of the conservation of the natural resources of the

country. The first item of the program was the report of the committee on this subject, and the president called upon Mr. M. N. Baker, who said:

"This committee was appointed a few months ago to take up the important question of the conservation of the natural resources of the country. It has seemed best to bring the subject before the convention in the form of papers by experts on those phases of it most important to our members. It was the intention to have papers on forestry, on water supply, and on coal. Unfortunately we were unable to secure a paper on coal; those on water supply and forestry will now be presented."

The first paper, entitled, "The Conservation of Water Resources," by Marshall O. Leighton, chief hydrographer, United States Geological Survey, Washington, D. C., was read by Mr. Horatio N. Parker."

An address on "Forestry," by R. S. Kellogg, of the United States Forest Service, Washington, D. C., followed, and the subject was discussed by Messrs. P. A. Maignen, Robert S. Weston, Allen Hazen, Frank L. Fuller, W. C. Hawley, Albert Blauvelt, M. N. Baker, H. N. Parker, Edward W. Bemis, George A. King, and A. A. Reimer. At the conclusion of the discussion President Martin said:

"Are we to understand that the committee is to be continued, and that we may have the pleasure of hearing something more from it in the future? This is a very important question and should be kept alive before the Association."

MR. BAKER. As I remember it, the appointment of the committee was at the suggestion of the Executive Committee of the Association because the subject was at the front, and the four leading national engineering societies had already appointed committees on the conservation of the natural resources of the country. What the pleasure of the Association may be as to continuing our committee I, of course, do not know.

THE PRESIDENT. Unless there is objection on the part of any of the members, this report will be received as a report of progress and the committee continued for further work. There being no objection to that it will be so understood.

Adjourned.

MORNING SESSION, THURSDAY, SEPTEMBER 24.

President Martin in the chair.

The Committee on Standard Specifications for Fire Hydrants presented the following report of progress:

BOSTON, MASS., September 17, 1908.

To the New England Water Works Association, — The committee appointed to prepare specifications for street hydrants has had two meetings, an afternoon having been devoted to each, with the result that a general outline of specifications has been prepared, but we have not been able to get this into proper shape for presentation to the convention next week. We, therefore, can only report progress at the present time, with the expectation of submitting a little later to the Association a specification in reasonably complete form.

H. O. LACOUNT, *Chairman.*

The first paper on the program for the morning was a "History of the Haverhill Water Works," by Albert A. Sawyer, water registrar, Haverhill, Mass. Its reading was supplemented by some general observations by Mr. M. N. Baker on the importance of the preservation of historical data in connection with water works.

Mr. R. S. Weston, sanitary expert, Boston, Mass., read a paper on "Rubber Pipe Joints." The subject was discussed by Mr. Allen Hazen, Professor Bemis, Mr. W. C. Hawley, Mr. Van Gilder, and Mr. Charles E. Chandler.

Mr. Frank L. Fuller, civil engineer, Boston, Mass., submitted a paper entitled "Covered Reservoirs; Some Experience in the Use of Concrete in their Construction and in making them Watertight." Following the reading of the paper Mr. Fuller showed a large number of lantern slides illustrating his subject, and the exhibition of those closed the morning session.

AFTERNOON SESSION, THURSDAY, SEPTEMBER 24.

President Martin in the chair.

The first paper of the afternoon was presented by Mr. Ermon M. Peck, distribution engineer, Hartford, Conn., his subject being "Meters and Water Consumption of the Hartford Water Works." Messrs. Allen Hazen, M. N. Baker, and H. N. Parker took part in the discussion.

A paper on "Meter Rates," by W. H. Richards, engineer and superintendent, New London, Conn., was read by Mr. George A. King. It was discussed by Prof. Bemis and Messrs. W. C. Hawley, A. A. Reimer, Hugh McLean, Albert Blauvelt, Leonard Metcalf, Frank L. Fuller, H. N. Parker, and J. H. Child.

Mr. Frank A. Barbour, civil engineer, Boston, Mass., presented a paper entitled, "The Water Service and Insurance Rates." Mr. Charles E. Chandler, Mr. Allen Hazen, and Mr. Leonard Metcalf took part in the discussion.

The regular program for the afternoon having been concluded, the President announced that Mr. Metcalf had in mind a matter which he desired to call to the attention of the convention.

Depth of Laying Water Pipes.

MR. LEONARD METCALF. There is a matter which I should like to bring before the Association, which it has seemed to me might furnish an interesting subject for investigation. Some time ago it occurred to me that we had very little tangible or valuable information concerning the desirable depth at which water pipes should be laid in different latitudes and under different conditions, and I set out to prepare, and did prepare, a schedule of questions which I purposed sending to different water-works departments, in the hope of getting some light on this question, and getting some statistics in regard to actual experience with frozen pipes. Then it occurred to me that greater weight would be given to the investigation, and perhaps there might be a readier response to inquiries, if the work were undertaken by the Association, particularly in the light of the admirable work which some of our committees have done. So I thought of making a motion at this time, that a committee of seven, or whatever number might seem desirable to you, be appointed to gather statistics relating to the depth at which water pipes are laid, and the resulting experience with frozen pipes, not only in New England, but in different parts of the country if the scope of the inquiry could be successfully extended.

In going over this matter, I discussed the question with some friends, and wrote one or two letters which drew forth some very

pertinent suggestions, it seemed to me, and those I should be very glad to turn over to the committee should it seem desirable to you to appoint such a committee.

It seems to me it is not sufficient to inquire simply as to the depth at which pipes are laid in different works, and the character of the material in which they are laid, but that we should go further and inquire particularly into the cases that have arisen of frozen pipes, covering in our inquiry, aside from the elements which I have mentioned, that perhaps most important of all, the consumption of water through those very pipes. It is only from experiences of that sort, I believe, we can get the definite, tangible information that we need.

THE PRESIDENT. Do I understand you make that motion?

MR. METCALF. I make that motion, Mr. President.

MR. HAZEN. I second the motion, Mr. President. I have been greatly impressed at times, in walking over pipe lines and examining them, to observe that they were very much nearer the surface of the ground than common practice would seem to justify, and nevertheless they have not frozen; and I have wondered whether it was really safe to put pipes so near the surface as that, and, if so, if we were not wasting lots of money in putting them deeper.

MR. H. N. PARKER. It seems to me this would be a very valuable inquiry, but I think to the duty of that committee should be added that of collecting data in regard to the size of pipe and length of pipe that may safely be exposed in going over bridges, etc., without danger of freezing. That is a question I have often heard brought up, and it seems to me a very practical question for many superintendents, if they have a line of pipe crossing a ravine or a bridge, — whether it is necessary to cover it. I would have that included in the investigation.

MR. METCALF. In that connection, Mr. President, it might also be interesting, in order that it may be a matter of record here, to suggest that there has doubtless been experience with penstocks which will furnish very interesting data on that line. I know one came to my attention up in Maine which, I think, was 4 feet in diameter and absolutely exposed, and which lay idle for certain hours in the day, and in which they prevented freezing by partly

opening a small gate,— I think it was something like three or four inches, — and they had no trouble from freezing or anchor ice.

THE PRESIDENT. I would like to ask Mr. Metcalf if he has his motion in writing, or, if not, if he will put it in writing so that it can be acted on.

MR. METCALF. The gist of the motion is that a committee be appointed to gather statistics relating to the depth at which pipes are laid and the resulting experience with frozen pipes.

THE PRESIDENT. And would you like to add Mr. Parker's suggestion?

MR. METCALF. I would be very glad to incorporate that. I did not wish in any way to limit the scope of inquiry of the committee.

MR. W. C. HAWLEY. I would suggest in connection with the investigation that the temperature of the water that is passing through the pipe is quite an important factor, and I suppose of course that will be considered.

THE PRESIDENT. These items, perhaps, might be brought out in the questions which will be sent out by the committee.

MR. METCALF. If there is no objection, Mr. President, I will furnish the schedule of questions as I had arranged them myself, in order that they may be a permanent matter of record, not in any way to limit the action of the committee, but simply for the use of the committee, leaving the committee entirely free to modify, extend, or cut out any questions they may wish.

(The motion that a committee be appointed was adopted.)

MR. ALLEN HAZEN. I am going to suggest, Mr. President, as one member of the committee, a member of the Association who is not here, Mr. Kuichling. I happen to know he has made many calculations along this line, especially along the line of Mr. Parker's suggestion in regard to exposed pipe.

THE PRESIDENT. I will take the matter into consideration and announce the committee at the beginning of the evening session.

(The President subsequently appointed as the committee Messrs. Frank A. Barbour, Boston; R. S. Lea, Montreal, Canada; W. C. Hawley, Wilkinsburg, Penn.; R. Winthrop Platt, Columbus, Ohio; Emil Kuichling, New York City; W. C. Hoad, Lawrence, Kan., and Dabney H. Maury, Peoria, Ill.)

(The following correspondence and schedule of questions sug-

gested for the consideration of the committee were submitted by Mr. Metcalf.)

NOVEMBER 6, 1907.

MR. LEONARD METCALF, BOSTON, MASS.

Dear Mr. Metcalf, — I am much interested in your proposed collection of data regarding the depth of water pipes. I regard the inquiry as a most important one.

I see your schedule is arranged to take into account most of the points that I should be interested in, and I will only make some very general suggestions regarding it. I have not studied it as carefully as I would do if I had more time before leaving for the West, so what I say may duplicate what you already have.

In the first place, I would try to get the data relating to the particular mains which are frozen, and make this point very clear so that those who fill out your blanks will not give you the depths, materials, etc., that are generally used. It seems to me that the inquiry will be much more valuable to limit it strictly to those places where trouble has actually been experienced.

Limiting it in this way to those points, I should be especially interested to know the size of pipe; the depth; the character of the soil, especially whether clayey and impervious or gravelly and pervious; and the height of the ground water, if any, over the pipe. These matters I believe are all indicated on your schedule.

I should also want to know especially the length of pipe so exposed, if the location was specially exposed, and I should want to know as to the flow of water through the pipe, whether it was rapid or slow, continuous or intermittent. These are very hard matters to tabulate, but it would seem to me that they are likely to be of controlling importance in this matter.

I would also suggest that you make a special study to see if there has been any reduction in carrying capacity of pipes in exposed positions during continued severe winter weather. I have been especially interested in the last years in seeing a number of important leading-mains supplying cities running for miles with but little covering. Last week I walked over a mile of pipe that did not have over six inches of cover, much of the way the bells of the pipe being exposed, and here and there whole lengths of pipe. This pipe has been in use some years and there has been no reason to think that it has ever given trouble from freezing.

Now it would seem to me that in very cold weather anchor-ice would form on the top and sides of this pipe and reduce the carrying capacity. I believe that it is common experience for the penstocks and draft tubes of water-power plants, which are commonly exposed, to have their carrying capacity reduced in this way, and

it would seem to me that some of these leading-mains would show a corresponding reduction in carrying capacity. So long as there was no necessity for using the main to the limit of its capacity at these times, this reduction in carrying capacity very likely would not be noticed, but it does seem to me that it would be likely to occur and that its occurrence would be a matter of great importance, which would necessarily have to be taken into account in making adequate calculations. This is the more important because the maximum use of water often comes at times of continued severe cold weather.

Hoping that these rough suggestions will be of some use to you, and assuring you that I shall be very glad to see the compilation of your data when it is ready, I am,

Very truly yours,

ALLEN HAZEN.

The President presented Mr. Albert Blauvelt, associate manager of the Western Factory Association, Chicago, Ill., who desired the privilege of the floor to make a statement.

MR. ALBERT BLAUVELT. Mr. President, my statement will be very brief. The National Fire Protection Association have a standing committee on pipe, of which I am chairman, and I have come to this meeting in the hope of meeting those of your members who are most informed on the subject of cast-iron pipe. It transpires that some of them, at least, are not present at this meeting, and therefore such information as I shall need in the discharge of my duty will have to be obtained at some succeeding meeting.

The National Fire Protection Association is desirous of adopting a standard for pipe, and it appears that there are two or three printed specifications in the field. I simply rise to have it made a matter of record that I have discharged my duty in putting in a representation here, and I hope it will be the feeling among you individually that in the course of two years or three years or four years or five years, or whatever time is necessary, the discrepancies in pipe specifications can be eliminated and a uniform specification arrived at. One reason for my presence here is that the National Fire Protection Association is in touch with the International Association, and we had very much rather have uniform specifications in this country before taking up any question of standards with the Europeans.

[*Inquiries suggested by Mr. Metcalf.*]

WATER WORKS.—STATISTICS RELATING TO DEPTH OF LAYING PIPES.

Date of Reply_____ Name_____ Official Position_____

_____ Water Works City or Town_____ State_____

(Municipal or Company Works. Give name if latter)

Distance of City from Ocean_____ miles
Mean Temperature, Deg. F._____°
Character of Supply_____
(Gravity or Pumping Supply)

Elevation above Sea_____ feet
Extreme Winter Temperatures_____°
Hours of Pumping daily_____
(24 hours or how many)

Approx. minimum hourly rate of pumpage during winter months_____
,, mean daily water pumpage during winter months_____

	Range of Diameters.	Approx. Length Miles.	Kinds.	Feet Depth of Laying to			Pipe laid by Contract or by the Company.
				Axis of Pipe.	Bottom of Trench.	Cover over Pipe.	
Supply Mains							
Distribution Mains							
Service Pipes							

	* Kind or Character of Soil.	Depth of Frost in Feet in Streets or Highways.		Depth of Frost in Feet in Fields, or Outside of Streets and Highways.
		General.	Extreme.	
Supply Mains				
Distribution Mains				
Service Pipes				

* Note: Rock, Hardpan, Clay, Sand or Gravel, Alluvial, mixed.

Approx. percentage in length of pipes below level of ground water _____%. Are water pipes laid at stated depth for other reasons than danger of freezing? If so, for what reasons? _____

If records have been kept of frozen pipes, kindly quote or abstract them below in the column of remarks, and fill in the following table, if possible:

	Winter of 1904–5.	Winter of 1905–6.	Winter of 1906–7.	Worst Winter in Recollection of Oldest Inhabitant.
Number of cases of frozen supply mains				
" " " " " distrib. "				
" " " " " service pipes				
Total length of feet of frozen supply mains				
" " " " " " distrib. "				
" " " " " " service pipes				

Is town or city sewered? _____ (Yes or No.) Name _____

I also wish to express the hope that the New England Water Works Association will become an active and voting member of the National Fire Protection Association, and that you will send us a voting delegate. That is being done now by a great many associations who are engaged in matters pertaining to construction or equipment in any way allied to fire protection. I thank you for your attention. [Applause.]

Adjourned.

Evening Session, Thursday, September 24.

President Martin in the chair.

The Secretary read the following names of applicants for membership, all properly endorsed and recommended by the Executive Committee:

Active. — Gilbert C. White, Durham, N. C., consulting hydraulic engineer; Albert L. Sessions, Bristol, Conn., president of the Bristol Water Company; Edwin L. Stone, Winchendon, Mass., engaged with the Winchendon Water Works; Albert Blauvelt, Chicago, Ill., associate manager Western Factory Association; Arthur L. Adams, Oakland, Cal., hydraulic engineer; H. J. Deutschbein, Albany, N. Y., superintendent Albany Water Works; W. C. Hoad, Lawrence, Kan., sanitary engineer, Kansas State Board of Health; R. Winthrop Pratt, Columbus, Ohio, chief engineer, Ohio State Board of Health; John S. Keinle, Wilmington Del., chief engineer Wilmington Water Company.

Associate. — East Jersey Pipe Company, New York, manufacturers of lock bar steel pipes and riveted steel pipes.

On motion of Mr. H. N. Parker the Secretary was directed to cast one ballot in favor of the election of the candidates whose names had been read, and, he having done so, they were declared duly elected members of the Association.

Mr. Leonard Metcalf, secretary of the Committee on Awards that have been made for Damages resulting from the Diversion of Water, reported progress for the committee as follows:

Progress Report of Committee on Awards that have been made for Damages resulting from the Diversion of Water.

Under a vote passed by this Association at its last annual con-

vention, held in Springfield, Mass., on September 12, 1907, the sub-joined committee of five was appointed by the President

"To collect data relating to awards that have been made for damages resulting from the diversion of water; also to consider the practicability of joint action with the National Cotton Manufacturers Association, or other organizations of mill owners, relating to the formation of standard rules for computing or assessing damages for the diversion of water."

Your committee has succeeded already in getting together a considerable amount of available data relating to water and water-power diversion suits, but it has seemed desirable to it, in order to broaden the scope of its work and to bring together as far as possible all available material, to send out a postal card inquiry to the members of this Association, as was recently done, asking members to contribute memoranda of any data or cases with which they might happen to be personally familiar, bearing upon the investigation under question, which they might be willing to place at the disposal of the committee. In this way, your committee hopes to acquire data relating to the valuations, sales, or awards for water or water-power diverted under right of eminent domain, of which it might otherwise fail to learn, and incidentally to prevent duplication of information and useless work on the part of active members of the Association in preparing the data. This card of inquiry was sent out with the last notices for this convention, and your committee is glad to be able to report that already a considerable number of encouraging replies have been received. Members who have not yet replied to the circular are urged to do so, in the interest of the Association and in the hope of broadening the scope of the inquiry as far as possible.

Your committee now has under advisement a general set of questions to be forwarded to members who have information along these lines, and have responded favorably to the earlier inquiry of the committee, to assist in the preparation and assembling of the facts in as concise and comparable form as possible. The proposed schedule now under consideration is submitted for friendly suggestion and criticism.

OUTLINE OF PROPOSED SCHEDULE OF QUESTIONS RELATING TO WATER AND WATER-POWER DIVERSION DATA, TO BE SENT TO MEMBERS OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

1. Data of valuation, sale, or award.
2. Amount thereof, exclusive of interest ($).
3. Total amount, including interest and allowances for collateral items.
4. Incorporated name of both parties.
5. Location, town, city, county, and state.
6. Character of privilege.
7. Total area of watershed taken or diverted.
8. Amount of watershed taken or diverted.
9. Amount of water taken or diverted.
10. Theoretical fall taken to which right was claimed.
11. Fall used or developed.
12. Hours per day during which power is used.

In addition to the above fundamental or elementary questions the following questions which will throw valuable light upon the information given will probably be appended in a separate group·

13. Character of development, product of mill, etc.
14. Character of watershed.
15. Cost of coal per 2 000 pounds and of electric current.
16. Is steam used for manufacturing or other purposes?
17. Is water used for any other purposes than for power?
18. Number of wheels installed.
19. Power of wheels.
20. Total steam and electric power development.
21. Total power required to run mill.
22. If supplementary steam or electricity is necessary, state amount.
23. What must be done to improve the privilege, or to develop undeveloped available power there, and cost thereof.
24. Approximate area of mill pond.
25. Approximate depth to which mill pond can be drained.
26. Are there other storage reservoirs upon the watershed? If so, state capacity.
27. Character of control of the storage.
28. What were the controlling factors in the award?
29. Did the award include any allowances other than for the water or water-power?

It has further seemed probable to your committee that for purposes of general standardization or comparison, so far as this

may prove feasible or desirable, the units of value or award in "$—— per square mile of watershed per foot of fall" and the "number of daily million gallons of water diverted per foot of fall," would prove the most satisfactory.

Acting upon the latter part of the vote under which your committee was appointed, after careful consideration of the subject, the conclusion was reached that it is impracticable for the committee "to formulate standard rules for computing and assessing damages for the diversion of water." The committee, with the exception of certain of its members, who modestly refrain from referring to their own work, though hoping to present later a bibliography of the subject, now recalls to the attention of the members of this Association the papers upon this subject published in the JOURNAL of this Association in September, 1907, p. 214 *et seq.*, which in its opinion furnish the best guide to the engineer in methods of computing and assessing damages for the diversion of water, but the committee recognizes that the question is one of law rather than of engineering practice, and that every suit is likely to involve some novel features, and must of course be considered in the light of local circumstances and conditions.

Recognizing the necessity and importance of the subject to the members of this Associaton and the fact that work has but just begun, your committee presents this progress report and asks to be continued.

Respectfully submitted,

CHARLES T. MAIN, *Chairman.*
CHARLES E. CHANDLER.
RICHARD A. HALE.
WILLIAM WHEELER.
LEONARD METCALF, *Secretary.*

Mr. Charles E. Chandler, civil engineer, Norwich, Conn., read a paper entitled "Stream Flow Data."

Mr. Robert E. Horton, hydraulic engineer, Albany, N. Y., submitted a paper, which was read by Mr. Leonard Metcalf, on "The Adjustment of Damages for Stream Diversion by Storage Compensation." Mr. Louis L. Tribus, Mr. Allen Hazen, Mr. T. H. McKenzie, and Mr. Metcalf spoke on the subject.

Mr. Allen Hazen reported for the Committee on Awards that have been made in Water Works Valuation Cases that the only action taken by the committee up to this time, so far as he knew, had been to elect Mr. Desmond FitzGerald chairman. The report was accepted as a report of progress.

Adjourned.

FRIDAY, SEPTEMBER 25, 1908.

This day was devoted to excursions to points of interest in and near Atlantic City.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at Plymouth, Mass., June 24, 1908.

Present: Messrs. Martin, Collins, Thomas, Bancroft, Sherman, Tower, and Kent.

Eleven applications received and the applicants recommended for membership, viz.:

Dana M. Wood, Frank A. Marston, H. Lester Newhall, Ira C. Forbes, Thomas Gray, James F. Sanborn, Nicholas S. Hill, Jr., Charles L. B. Anderson, C. S. Rex, Jr.,F. C. Hersey, Jr., and Henry A. Young.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association held at Atlantic City, N. J., Thursday, September 24, 1908.

Present: President Alfred E. Martin and members M. N. Baker, George A. King, D. N. Tower, Robert J. Thomas, George W. Batchelder, and Willard Kent.

The following applications were received and approved for membership, viz.:

Gilbert C. White, hydraulic engineer, Durham, N. C.; Albert S. Sessions, president Bristol Water Company, Bristol, Conn.; Edwin L. Stone, Winchendon, Mass.; Albert Blauvelt, associate manager Western Factory Association, Chicago, Ill.; Arthur L. Adams, hydraulic engineer, Oakland, Cal.; H. J. Deutschbeim, superintendent water works, Albany, N. Y.; W. C. Hoad, sanitary engineer, Kansas State of Board Health, Lawrence, Kan.; R. Winthrop Pratt, chief engineer Ohio State Board of Health, Columbus, Ohio; John S. Kieule, chief engineer Water Department, Wilmington, Del.

Associate. — East Jersey Pipe Company, manufacturers of lock bar steel pipe and riveted steel pipe, 90 West Street, New York City.

Adjourned.

WILLARD KENT, *Secretary.*

OBITUARY.

GEORGE E. WILDE died very suddenly of heart disease at the office of the Metropolitan Water and Sewerage Board, in Boston, on July 17, 1908. Mr. Wilde was born in Duxbury, Mass., January 29, 1850, and received his early education in an academy in that town. At the age of fourteen he began a seafaring life, which was continued for seventeen years, during which time he made voyages to Spain, Italy, India, Philippine Islands, Germany, Australia, England, and China, and rose from cabin boy to the position of first mate. From 1881 to 1884 he was employed as a foreman in the water department of the city of Worcester, Mass., and during the following six years was employed by A. H. Howland in constructing water-works plants in the middle West. In 1890 he became superintendent of one of these plants at Menominee, Mich., and remained there until 1896, when he returned to Massachusetts and connected himself with the Metropolitan Water Works, the construction of which was then beginning. On December 14, 1897, he was appointed assistant superintendent of the Distribution Department, having charge of the pipe lines and reservoirs of the Metropolitan Water Works within the Metropolitan District, which office he held until his death. He was married in 1879 to Angie C. Joyce, of Duxbury, who, with his son and daughter, survives him. He was elected a member of this Association on June 16, 1886.

IRVING T. FARNHAM, city engineer of Newton, Mass., died September 19, 1908. Mr. Farnham was born in Deposit, N. Y., in 1869. He was graduated from the College of Civil Engineering of Cornell University in 1892. After a few months' service as draftsman for the Elmira Bridge Company, he went to Newton and entered the city engineer's office. He was engaged in im-

portant work for the city until 1899, when he became principal assistant engineer for the Massachusetts Highway Commission. He held this position only about a year, as he became city engineer of Newton in 1900 and remained in that office until his death. During his term of office he had carried out many important pieces of work for the city. He is survived by a wife and four children. Mr. Farnham was a member of the American Society of Civil Engineers and the Boston Society of Civil Engineers. He was elected a member of the New England Water Works Association on December 13, 1905.

BOOK REVIEWS.

TYPHOID FEVER: ITS CAUSATION, TRANSMISSION, AND PREVENTION. By George C. Whipple. xxxvi, 408 pages. 5½ x 8 inches. New York: John Wiley & Sons. 1908. Price $3.00.

The author says in his preface: "The object of this book is to furnish to the members of these two professions [physicians and engineers] a condensed summary of the most important facts that have been learned regarding typhoid fever so far as they relate to the prevention and spread of the disease; to furnish to the student of sanitary science a group of illustrations of some of the leading principles of epidemiology; and to give to the general reader a simple and, it is to be hoped, a clear and correct account of the causation, transmission, and prevention of the disease, and his own responsibility in helping to bring about such conditions of cleanliness that typhoid fever shall soon cease to be a national disgrace."

The members of this Association, to which some of the best papers descriptive of typhoid fever epidemics have been presented, should welcome the present volume. Mr. Whipple has long been known to them as an authority in this field, and as a clear and forceful writer. He has succeeded well in his task, and it is much to be desired that every person who has any responsibility for the quality of a water supply should read this book carefully.

The author concludes that in a general way about 40 per cent. of the typhoid fever in the United States is due to infected water, 25 per cent. to milk, 30 per cent. to ordinary contagion (including transmission by flies), and 5 per cent. to other causes. Thus, in spite of the great improvement in the quality of public water supplies that has been made in recent years, water still remains the most important single cause of the spread of typhoid fever, and it behooves all water-works men to have a clear understanding of the subject, not only that they may suitably protect the water supplies committed to their charge, but also to assist them in placing the responsibility for typhoid cases or even epidemics which may be unjustly charged to the water supply.

From the point of view of the sanitary engineer, it is difficult to imagine a question upon typhoid fever which is not answered in this book. It makes no pretense of treating the subject from a medical standpoint, although the symptoms and the bacteriology of the disease are described with some detail, and in the appendices are described the tests of diagnosis, the bacteriology of the blood, and the methods of examination of water for bacillus typhi.

The book is illustrated by a large number of diagrams and contains a number of tables, particularly of populations and typhoid fever death-rates. There is an excellent index.

NOTES ON HYDRO-ELECTRIC DEVELOPMENTS. By Preston Player. 68 pages. 5 x 7½ inches. New York: McGraw Publishing Company. 1908. Price $1.00.

This little book was written primarily for the purpose of presenting a general treatment of the subject set forth in the title, dealing particularly with the commercial side of the matter, in such a manner as to be acceptable to investors, capitalists, and bankers. It is difficult to see how this book can even in slight measure, fulfill the requirement. It is a carelessly written and very poorly edited book. Its treatment of the subject is so "general" as to be decidedly incomplete, yet technical terms are used so freely and with so little explanation of their meaning that it can hardly be intelligible to the classes for whom it was particularly written.

The titles of the chapters are as follows: Preliminary Determinations; Methods of Procedure; Engineering Examination; The Extent of the Market for Energy; Cost of Energy Manufacture; Central Station Economics; Sale of Electric Energy; Primary and Secondary Powers; Capital Costs.

TRADE PUBLICATIONS.

The Thirty-Ninth Street Sewage Pumping Station (Chicago, Ill.). Allis-Chalmers Company, Pumping Engine Department. Bulletin No. 1611, May, 1908.

This bulletin describes the equipment of a sewage pumping station having a capacity of 2 160 000 000 gallons per day, which contains two screw pumps, of the type first used for flushing pumps at Milwaukee, and four vertical centrifugal pumps. The latter are driven by horizontal triple expansion engines, with the cylinders set 120 degrees apart; the screw pumps are driven by vertical triple expansion engines. The boilers, condensers, piping, and coal handling systems are also briefly described

The Manhattan High-Pressure Fire Service System. Allis-Chalmers Company, Pumping Engine Department. Bulletin No. 1614, August, 1908.

This bulletin describes the high-pressure fire system of New York City, about which so much has been said of late. This system consists of main pipes and hydrants independent of the regular water-works system, to which water is furnished under unusually high pressures (300 pounds or more per square inch) by two pumping stations equipped with multi-stage centrifugal pumps, driven by electric motors.

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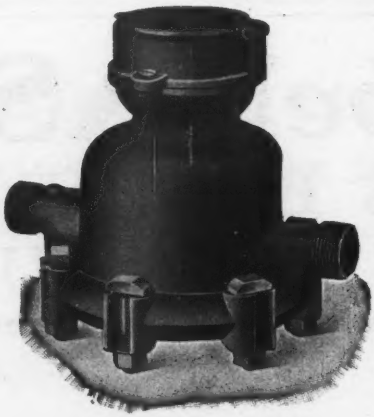

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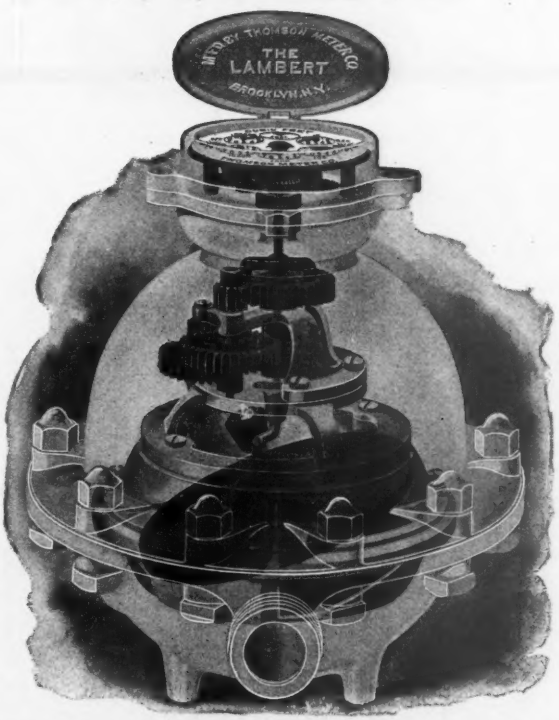

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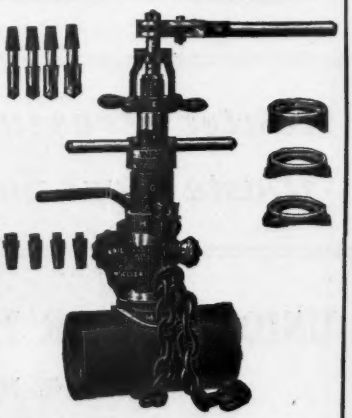

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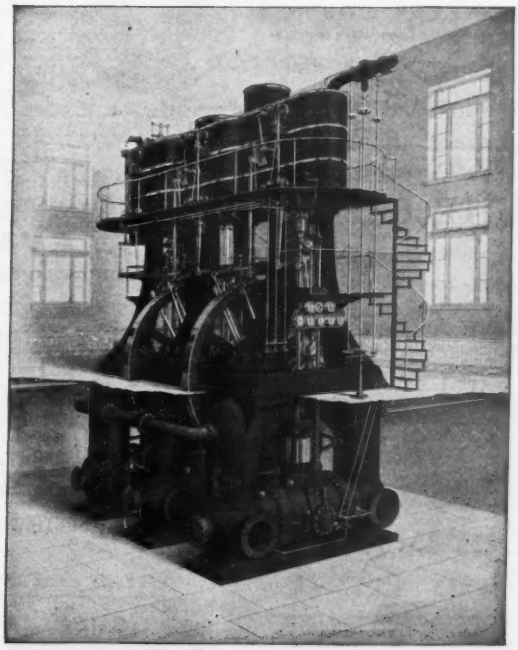

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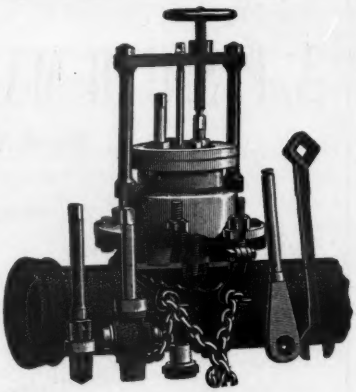

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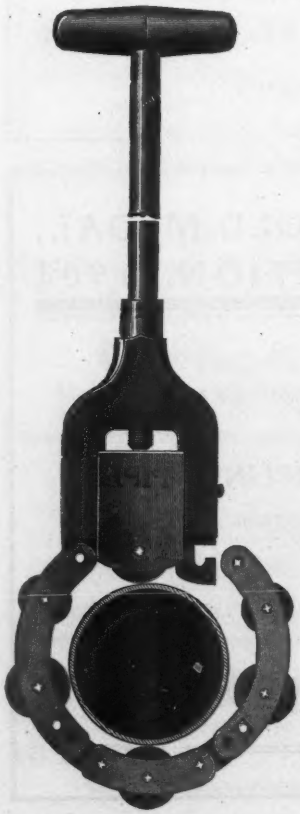

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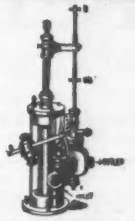

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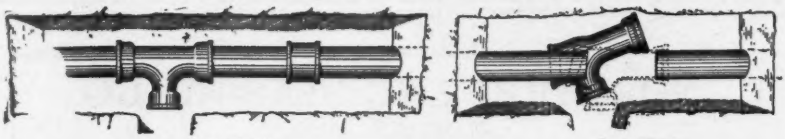

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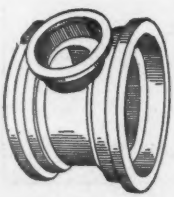

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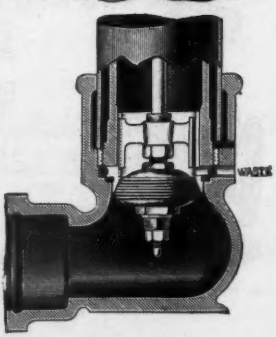

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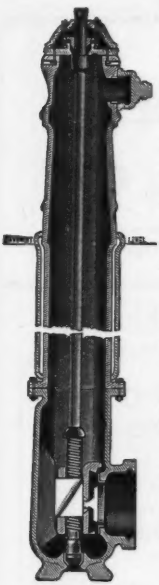

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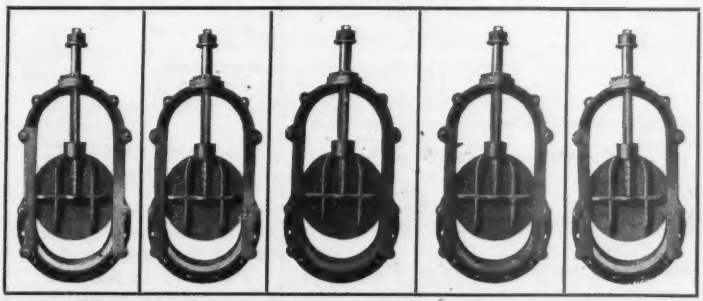

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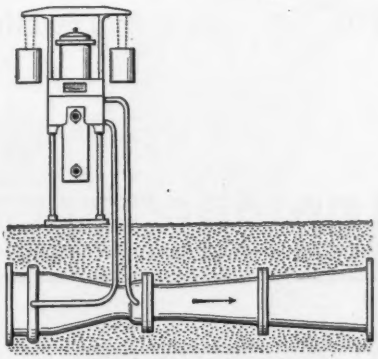

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